Grant Final Report

Grant ID: 1UC1HS015076

Transforming Healthcare Quality through Information Technology

Inclusive Dates: Not provided.

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Submitted to:
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Abstract

Purpose: This report summarizes the results of AHRQ Grant #1UC1HS015076-01, the objective of which was to introduce an advanced Electronic Medical Record (EMR) System at Cleveland Clinic Health System, Huron Hospital site.

Scope: In October 2004, CCHS-East began to implement a comprehensive EMR system that integrates Physician Order Entry, Medication Management and Nursing documentation at Huron Hospital. The project plan established three global objectives: (1) Patient Care: Improve the quality of patient care, through better reporting and reduced risk of error, as well as improved monitoring of chronic disease related complications, including Diabetes, Congestive Heart Failure, End-Stage Renal Failure and COPD/Asthma; (2) Care Provider Adoption: Establish conditions for adoption by care providers (including CPOE) and integrate the EMR system into the curriculum of the Huron Hospital School of Nursing; (3) Administrative: Achieve administrative gains in efficiency from improved utilization of resources and cost savings from technology, through lower form cost, reduced duplicate ordering, lower pharmacy calls and interventions, and lower readmission rates.

Methods: Three sources of data were used to evaluate the attainment of the objectives: (i) internal administration reports, (ii) EMR system reports and (iii) survey responses of employees from all groups using the EMR system.

Results: The results of the analyses show that the EMR system has been successfully introduced into the patient care practice and has achieved most of the intended objectives. A testament to its success is the ability of the organization to introduce additional processes through customized order sets, services such as online discharge, and new devices such as electronic medication carts and personal notebook computers that rely on the EMR and its infrastructure backbone. Over time, the availability of these new services may be a stronger motivator for physician adoption than the EMR technology by itself.A shorter treatment time was an unanticipated benefit of the EMR. This resulted in an increased cost per patient-day, but led to a reduction in the overall cost of treatment per discharge, and improved patient outcomes, as measured by the top 25 observation days. In addition, a direct relationship was found between the order set utilization by physicians and the benefits provided by the EMR technology. Positive attitudes and opinions about the EMR technology in adopters, whose use of the EMR was mandated were directly related to the amount of exposure and use of the technology for patient treatment. For attending physicians, whose use of the EMR is voluntary, a highly positive opinion of the technology was observed; nevertheless many chose not to use the EMR. These physicians had no problem accessing information and gaining the benefit from the technology, but did not use it to the degree that other care providers did. Care provider measures of the EMR also show improvements in the quality of care. Collection of information regarding vaccinations and chronic conditions, which was episodic at best in the paper charts, is now at 100%, due to the compulsory completion required by the EMR system. Overall figures show over 75% of all orders and over 90% of resident orders are processed through the EMR. The information we have available shows that the reported category B and C errors are on average down 66% for

category B and 50% for category in comparison to rate in the period prior to the introduction of the EMR.

Key Words: none provided

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Final Report

Purpose

The specific objectives presented in the proposal for the grant were focused in three areas. The first area dealt with the introduction of the EMR system as a tool to improve the quality of patient care. Specific measurable outcomes include decreased length of stay, reduced duplicate testing, improved radiology and lab utilization, reduced variability of patient care practice, and an overall reduction in the cost of healthcare. These objectives were measured in two ways. Improvement in performance of specific functional areas and the treatment process, as well as the lower cost of care, were measured using administrative performance data. Intangible outcomes such as the standardization of patient care practice, reduced adverse drug events, and reduced medication errors were achieved by changing the work processes, and the development and introduction of order sets which contain EMR–based rules and guidelines for treatment following current best practice. These rules are specifically focused in managing four major chronic conditions: Diabetes, Congestive Heart Failure, End-Stage Renal Failure and COPD Asthma. All are widely prevalent in the local population served by Huron Hospital. The ability of the EMR technology to apply and monitor care provider adherence to the treatment rules and guidelines specified by the order sets is a critical factor in raising the standard of treatment for these conditions. Hands-on application of the order sets and extracting benefit from their use depends on adoption of the EMR technology by all classes of users and the functions involved in patient care.

A survey-based methodology was used to assess the attitudes and opinions of care providers regarding the EMR technology. The goal of this evaluation was to understand whether care providers whose use is mandated by Huron Hospital are satisfied with their work, hence reducing turnover, absenteeism and other morale-related problems. The survey also evaluated opinions and the likelihood of adoption by attending physicians, in order to make sure the hospital administration did everything possible to encourage adoption.

This report is in six sections. It starts with an overview of the milestones which form the implementation effort to establish the EMR system and the processes associated with it. Next is a discussion of the measurement methodology, which is followed by an assessment of each of the key performance objectives. The report concludes with a brief discussion of the results and opportunities for future development.

Scope

Key Project Milestones (Based on Quarterly Reports)

This section is summarizes the specific milestones completed for the realization of the project. It is in three sections: (i) infrastructure milestones carried-out to enable and expand the reach of the technology, (ii) deployment of EMR system modules and their subsequent upgrades,

and (iii) Changes to the CCHS organization and processes that enable the new workflow resulting from the introduction of the EMR system.

Infrastructure Development Milestones.

- Upgrade connectivity and install new PC hardware at East Cleveland Primary Care physician office practice to facilitate remote access for MMG physicians who practice at Huron Hospital, 2nd quarter 2005

- Create new PC lab for Huron School of Nursing to facilitate implementing an EMR curriculum, 2nd quarter 2005

EMR Deployment Milestones.

- Upgrade core application to latest release (SCM 3.6) May 15, 2005
    - Create training materials and train end-users
    - Implement SCM 3.6 at Huron and Euclid
- Implement on-line medication administration record (eMAR) at Huron Hospital, 2nd quarter 2005
- Implement additional medical logic module (MLM) to calculate estimated creatinine clearance from existing lab values, 2nd quarter 2005
- Implement the capability to view a pertinent lab result from the order entry form for radiology test orders, 2nd quarter 2005
- Implement pilot "called MLM" which allows the system to invoke an MLM from a trigger event – the trigger event is a PRN medication order. The called MLM will fire an alert requiring a reason for the PRN order, 2nd quarter 2005
- Implement initial clinical documentation (flow sheets), 4th quarter 2005
- Deploy Emergency Department module, 1st quarter 2006
    - Implement integrated pharmacy module (Sunrise Medication Management)
    - Install SCM 4.0 in test and begin pharmacy build, 2nd quarter 2005
    - Install SCM 4.5 in test for pharmacy and general build, 3rd quarter 2005
    - Complete pharmacy build and begin testing, 4th quarter 2005
- Go-live SCM 4.5, including pharmacy, 1st quarter 2006

- Assess the CCHS-East Active Directory environment in preparation for migration to CCHS-Central region environment 3rd quarter 2005

- Migrate the CCHS-East Active Directory environment to CCHS-Central region Active Directory environment 4th quarter 2005 through 1st quarter 2006. This will facilitate system-wide integration of clinical data within a centralized repository

- Implement collaborative build process for CCHS-wide implementation of integrated EMR

Organizational and Process Change Milestones.

- Introduce EMR curriculum at Huron Hospital School of Nursing, 3rd quarter 2005

- Create new PC lab for Huron School of Nursing to facilitate implementing an EMR curriculum, 3rd quarter 2005

- Introduce EMR curriculum at Huron Hospital School of Nursing, 3rd quarter 2005

Project Management Milestones.

- Plan for implementation of EMR order entry and results reporting, 1st quarter 2005

- Implement project evaluation measures with Case Western Reserve University Weatherhead School of Management staff

    - Pilot data collection 1st and 2nd quarter 2005

    - Optimize survey instrument 2nd and 3rd quarter 2005

    - Round 1 survey data collection (nurses, resident physicians and ancillary staff) 3rd quarter 2005

    - School of Nursing survey data collection 1st and 2nd quarter 2006

    - Round 2 survey data collection Attending and Resident physicians 4th quarter 2006

    - Collection and Analysis of Huron Hospital performance measures 1st-3rd quarter 2007

Measurement and Evaluation Methodology

Evaluation of the performance and impact of the EMR technology was operationalized using three independent sources of data. These included measures from the patient care process supplied by internal administrative reports of CCHS, measures of EMR system use, and survey data collected from all user types to evaluate the attitudes and opinions of care providers. The

use of data from three separate sources provides us with a robust picture of the various aspects of EMR use at Huron Hospital and the impact of the technology on the performance of the organization as a whole.

Performance Measures. The administrative measures supplied by the CCHS administration provide an overview of critical indicators which evaluate monthly patient care performance over a 36 month period, 18 months prior and 18 months after the introduction of the EMR system. The measures are listed in Table 1:

Table 1. Patient care performance outcomes

Benefit type	Benefit
Healthcare Benefit	Length of Stay
Healthcare Benefit	Re-admission rate
Healthcare Benefit	Number of Infections
Healthcare Benefit	Preventable Drug Events
Economic Benefit	Cost/Discharge
Economic Benefit	Laboratory testing and radiology costs (Duplicates)
Economic Benefit	Pharmaceutical and medication costs

The main analysis involving the measures of performance of the patient care process focused on comparing the change in average performance in the periods prior to and after the introduction of the technology. This was carried out using a three month weighted average of the measures in order to smooth out variability in the data caused by non-periodic (single time) events. A secondary analysis looked at causal relationships between EMR orders and patient care performance measures.

Methods

Survey data was collected several times starting 6 months after the deployment of and ending 18 months after the introduction of the EMR system. It was collected from all functions and types of users involved in the process of patient care including nurses, residents and attending physicians. Surveys were also collected from radiologists, pharmacists and lab technicians who are not directly involved in patient care.

The objective of the survey was to evaluate the attitudes and opinions of all user types and understand whether or not they approved of the application of the EMR system in the healthcare process.

Data collection took place in three phases: a study pilot, and two rounds of data collection. The pilot tested the suitability of attitudinal measures in the context of patient care and the EMR technology. The 1st phase focused on hospital employees whose use of the EMR was mandated. The main objective was to determine whether users had favorable opinions of the technology and were satisfied with its use in their work. Users who were surveyed included nurses, lab technicians, radiologists, pharmacists and residents.

The 2nd phase focused on the overall impact of exposure to the EMR technology and evaluated the long-term adoption of the technology. Data for this phase was collected from

students in the school of nursing, resident and attending physicians, and also included nurses, lab technicians, radiologists and pharmacists.

The surveys included measurement items used in published scientific research. Each measure was evaluated multiple times in order to ensure consistency in the evaluation of the specific attitude provided by the respondent. The measurement items in the survey were agree/disagree statements regarding use of the EMR technology and the context in which it operates. Table 2 provides a list of the factors which were measured to assess respondent opinions and Appendix A contains the survey.

Table 2. Measures assessing EMR acceptance and fit with provider practice

Survey Measures and Predictors of Adoption
Perceived usefulness
Ease of use
Information quality
Information overload
Self-efficacy and perceived behavioral control
Subjective norms
Organizational support
Image maintenance
Work interdependence
Technical support

Specifics of the measurement validation process (factor analysis) and the structural models (regressions and SEM analysis) can be obtained from the researchers the Weatherhead School of Management.

Measuring EMR Use. EMR use measures determine the degree of interaction of care providers and the EMR technology beyond order entry. These measures are based on the assumption that the interaction of users and the technology requires more than just the signing of treatment orders, but instead requires consistent periodic interaction using multiple features of the technology which culminates in CPOE work.

The measures listed in Table 3 were extracted from the EMR usage logs for select users who had provided their consent.

Table 3. Measures of EMR use

Measure
Overall number of logins
EMR frequency of use
Specific workstations at which the EMR was accessed
Specific hospital units where the EMR was accessed

The measures of interaction with the EMR technology were used in conjunction with survey data in order to evaluate the degree to which exposure to the technology was related to the opinions provided by respondents. A secondary objective was to compare the opinions of physicians who are intensive users and those who use the EMR less or not at all.

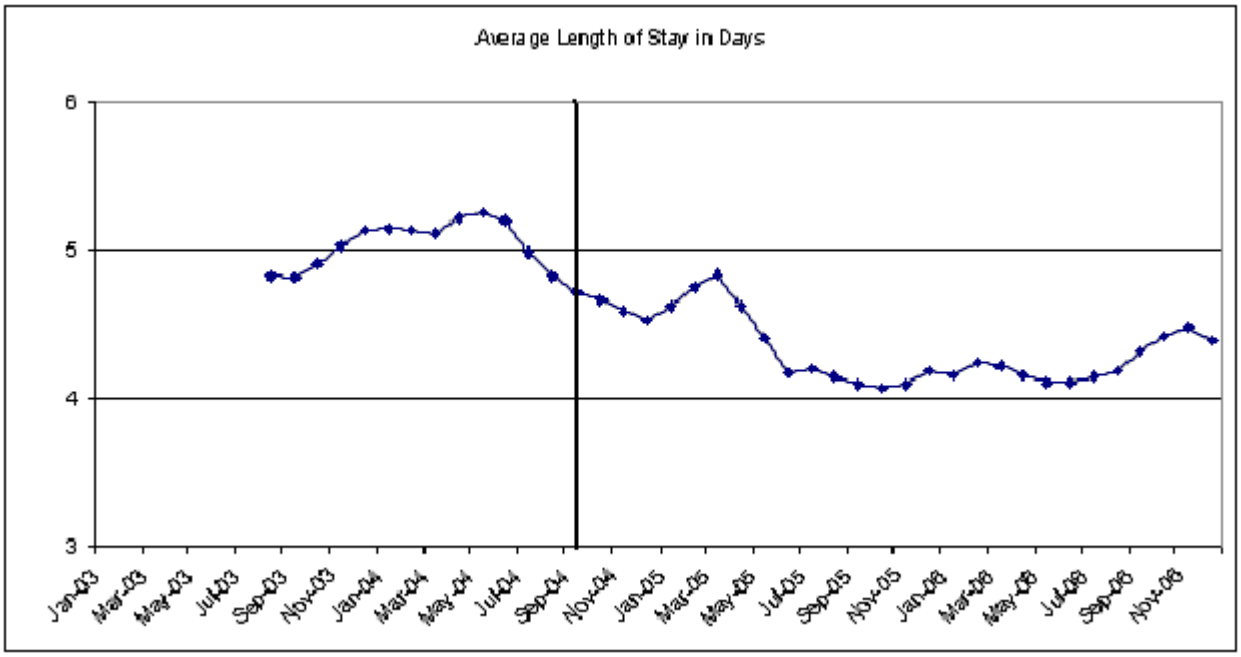
Results

Clinical Outcomes

Overview. The line graphs in Figures 1and 2 show the change in patient care indicators. The data covers a period of 3 years – 15 to 18 months prior the introduction of the EMR in September of 2004 and 18 months after that introduction. A moving average was applied to the data in order to allow evaluation of the mean level for each indicator, and the change in that level from the time prior to the time after the introduction of the EMR technology.

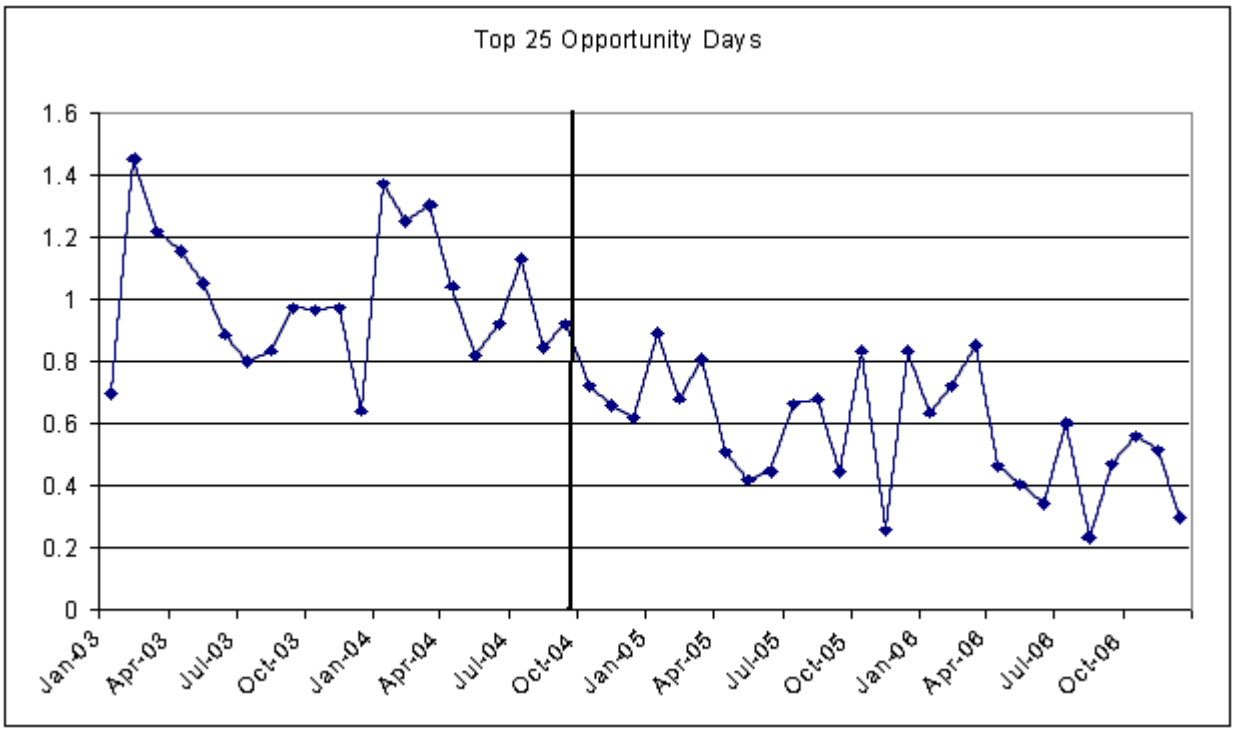
The means show that the average length of stay was reduced from 5.05 to 4.37 days, which represents a reduction of 13.5% after the introduction of the EMR.

Figure 1. Change in length of stay over time



The measure for Top 25 Opportunity Days fell from 1.03 to 0.614, with the measure still settling towards a new level (later measures show lower levels lower than 0.614).

Figure 2. Change in top 25 opportunity days



Patient Care Metrics. One of the important advantages gained by the introduction of the EMR system is in the expanded ability to collect patient data and options available for presenting the information. When using the paper charts, nurses collected data in the patient chart by exception. The EMR technology allows easier and more complete input of information on patient status, which allows the collection of a more comprehensive record of the patient treatment process than was previously possible.

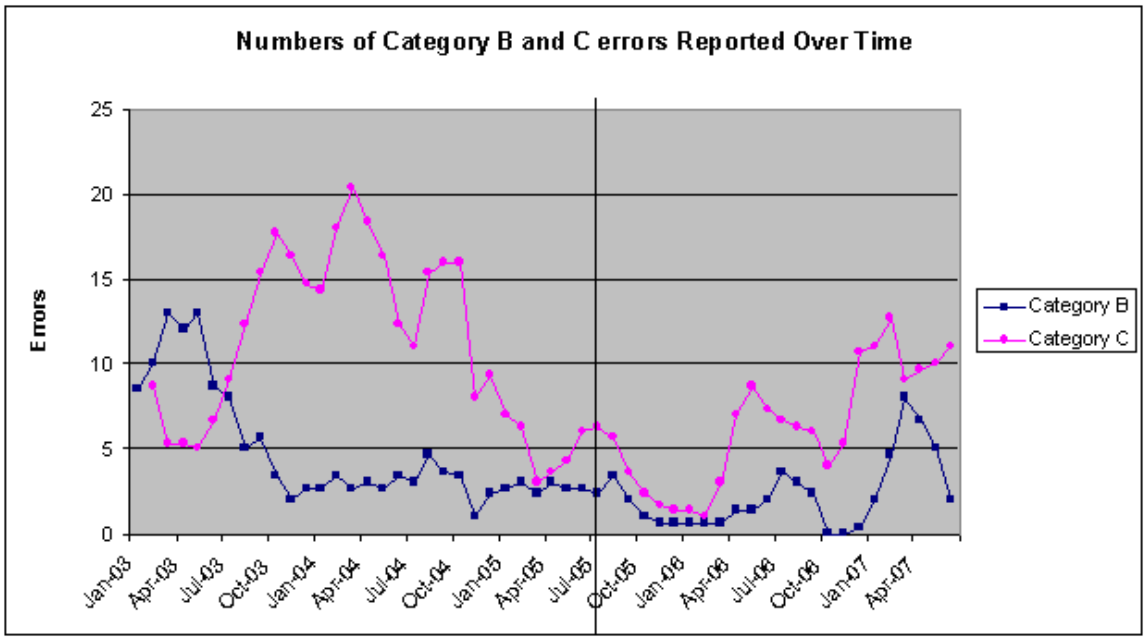
Table 4 provides an overview of the infection rate metrics as recorded by the EMR system. The data available is not sufficient to determine the effect of the EMR implementation statistically.

Table 4. Infection rates 2003-2007

Year	Surgery Site	Central line related 'Bacteremias Rate 'per 1000/central line days	Vent Associated Pneumonia Rate per 1000/ Vent days
2003	1.5	0.8	no data
2004	1.5	0.6	no data
2005	1.3	1.2	2.4
2006	2.1	0.3	1.7
2007	1.1	0	0

The number of errors reported over the observation period has declined over the period data is available. Our analysis showed that the average level of the category B errors has dropped from 6.08 to 2.01 per 1,000 since the introduction of the EMR system and the category C the drop is from 12.56 to 6.48 per 1,000.

Figure 3. Change in the number of errors reported



The overview of unsigned orders shows that the EMR technology provides an additional option to physicians wishing to sign-off on their treatment orders. The non-compulsory nature of EMR use and the lack of compliance logic in the order entry system for physicians means that those who have the highest numbers of unsigned orders using the paper system also have the highest number unsigned orders in the EMR i.e. the behavior observed with paper-based treatment orders is replicated in the process of order sign-off using the EMR.

Key Success Factors. Two factors contributed to the successful deployment and subsequent adoption of the EMR technology. The first was the establishment of processes and procedures that facilitated the deployment of the technology and organized the development, approval and implementation of *order sets* in the patient care process. Communication and promotion of the technology were executed in advance of the actual deployment effort. Part of this effort also included the establishment of physician champions. Their role was to help establish the changes in process and procedure, to promote the EMR technology, and facilitate adoption among attending physicians. Training of staff took place well ahead of the actual go-live date.

The physician champions also served as contacts to support the development of *order sets* for specific functions. The procedure for development and approval of *order sets* ensured that physicians in each specific function would be responsible for creating their *order set* in compliance with current best practice guidelines. The *order set* would then be reviewed and approved by various physician committees. The process that was established allowed creation of *order sets* by the physicians who would ultimately be using them and ensured compliance with current best practice guidelines.

The second contribution to the success of the EMR were the projects that built onto the technological infrastructure provided by the system, such as Medication carts, tablet PCs for pharmacists and residents, and implementation of an online discharge procedure.

Our feedback from nurses using the new carts showed that while the overall satisfaction and usefulness of the new carts was marginally better to the previous options, there was a significant improvement in patient safety and improved documentation during the administering of medication. Efforts on this project have subsequently focused on identifying a med-cart design that fits with the specific work conditions of Huron Hospital.

The tablet PCs were first assigned to pharmacists working with physician and nursing staff on the floors. The feedback was so positive that the trial program was expanded to cover additional pharmacy staff as well as resident physicians who can use the EMR technology at the patient bedside, thus reducing the distance information travels from its origin at the patient bedside to a computer out in the corridor.

The online discharge procedure was another successful implementation that relies on the EMR system. It allows the physician and nurse who are discharging a patient to receive all the relevant information about medication and patient training at the bedside, while simultaneously completing the information necessary for the discharge process. The initial 40% adoption rate jumped to 100% within several months of introduction. The discharge tool format was used to establish a communication and hand-off tool that facilitates nursing shift changes and physician to physician care hand-off. The impact of this tool is a more secure transfer of information across care providers working different shifts.

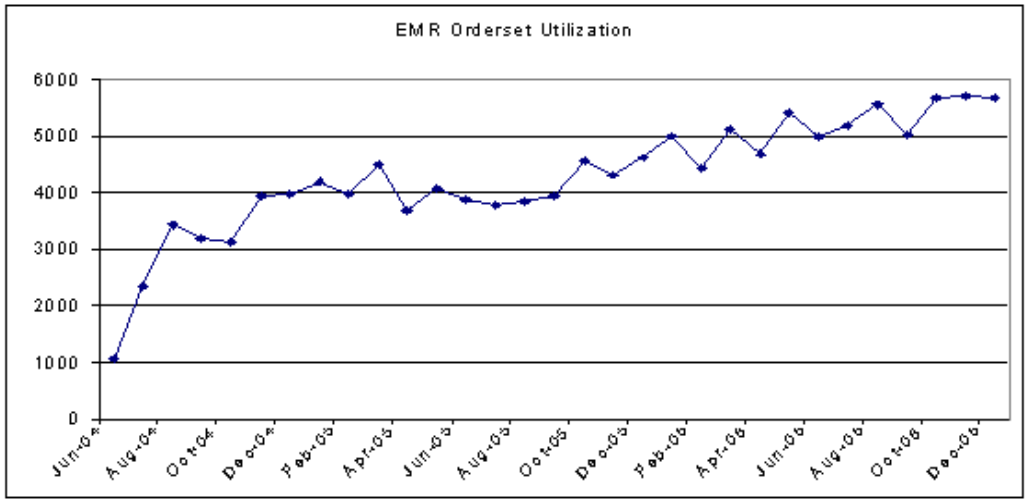
Despite the high diversity of inputs and outputs that characterize the hospital organization, the analysis of information made available shows that the performance of Huron Hospital has improved since the deployment of the EMR. We can ascertain that an important reason for the improvement lies in the use of the EMR technology; however, we cannot scientifically point specifically to the EMR as the sole reason without expanding the current assessment to compare to similar sites that do not have the technology in place.

Care Provider Adoption

Overview

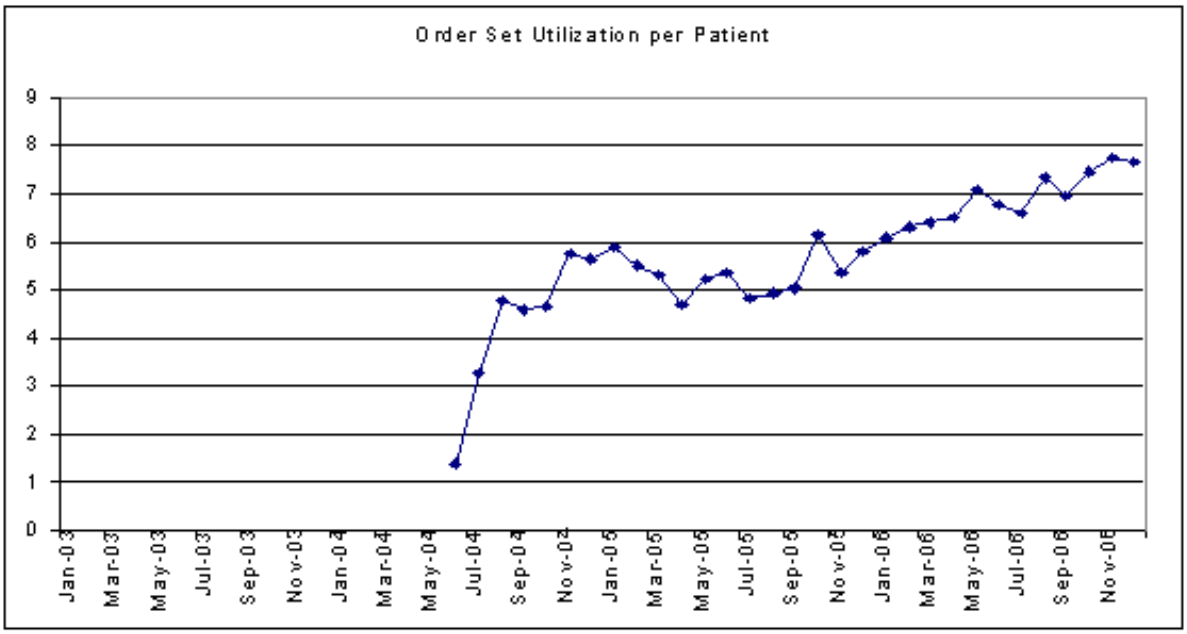
The basic measure of EMR utilization as represented by the *order set* utilization in Figures 4 and 5 shows increasing use of the EMR over the period that data is available.

Figure 4. Increase of the overall EMR CPOE utilization over time



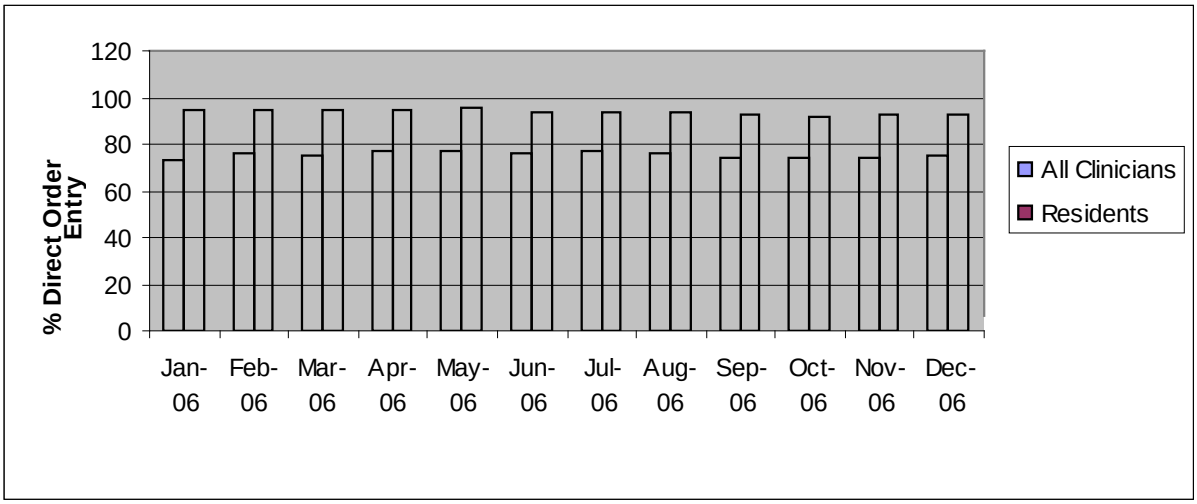
The measure describing the number of orders placed in the EMR per patients shows a similar pattern of increasing number of orders.

Figure 5. Increased utilization of EMR order set per patient over time



The levels for direct order entry during 2006 show a consistent and stable level of adoption. As Figure 6 shows, the general level of Computerized Physician Order Entry (CPOE) is over 70% for all clinicians, with residents carrying out over 90% of their orders through the EMR.

Figure 6. Direct order entry by clinicians during 2006



Survey Data Results. In the pilot and Phase I of survey data collection, unit secretaries, nurses, resident physicians and technical and ancillary staff, whose use of the technology is mandated, were the focus of the research. 143 responses were collected by researchers who are not affiliated with Huron Hospital, ensuring the free expression of opinions. The measures use a point scale from 1 to 7, where 1 represents a very poor opinion, 4 – neutral and 7 a high opinion about that aspect of technology use. Table 5 presents the results of the pilot study. The means of all EMR attitudes and opinions are positive. The measures addressing support from the organization and staff, as well as the availability of resources, show very high approval from respondents. The data also shows that EMR users do not enjoy an elevated image in the organization, so novelty image does not act as a motivator to adopt the technology. Overall usefulness of the EMR in treatment is between slightly positive and positive. It is slightly lower for the users involved in patient care versus technical, ancillary staff and secretaries, possibly because technology plays a support role in the actual patient care work. Compatibility with patient care is above 5 on the 7 point scale for all groups.

The control variables addressing past experience working with computers and within the healthcare setting fall within the expected ranges with resident physicians showing the lowest tenure in healthcare and exposure to personal computers due to their lower relative age.

Table 5. Measures acceptance and fit with provider practice for the various EMR user groups

Attitudes and Opinions	Secretary	Nurse	Technician	Resident Physician	Overall
Completed Surveys (n)	13	50	53	27	143
EMR Learning	6.35	5.47	5.74	5.76	5.70
Resource Availability	5.58	4.82	4.90	5.54	5.05
User Image	3.77	3.09	3.36	4.38	3.49
Compatibility with Patientcare	5.06	5.01	5.20	5.35	5.15
IT support	5.72	4.73	5.16	5.65	5.16
Support from Hospital Management	5.96	5.76	5.86	6.07	5.87
Overall Usefulness of the EMR	4.69	4.82	4.64	4.04	4.60
Experience Using Computers(years)	13.38	9.87	13.28	8.39	11.26
Tenure in Healthcare(years)	19.92	16.64	17.84	5.98	15.64

Table 6. Attitudes of Resident and Attending Physicians (on a 7-point scale)

	Resident Physicians	Attending Physicians
Ease of learning and adoption (1 disagree - 7 agree)	5.94	5.07
Overall usefulness of the Technology (1 disagree - 7 agree)	5.86	4.98
Tenure in Healthcare (years)	5.23	21.22
Experience using computers (years)	11.00	13.67
Age (years)	30.68	49.42
Average Logins per week	89.82	27.96
Workstations Used to access EMR	68.74	30.86

Overall the individual level data suggests that users are pleased with the performance of the EMR technology. While there are issues with the secondary role technology plays in the treatment process, the staff approves of the new workflows and practices introduced by the technology. Our conclusions are based on a total sample collected during the survey process of over 450 Nursing students, Nurses, Technician and Allied health professionals, Residents and Attending Physicians who use the technology.

Conclusion

Overview of Issues. The findings from the evaluation of the EMR project presented in this report show that the project was successful. The EMR system and its supporting IT-based infrastructure were deployed successfully. The hospital management carried out the appropriate training, institutional support for introduction of the EMR in the curriculum, as well as changes to patient care workflow, to integrate the EMR system with other patient care practices. The diverse patient care and operational metrics, as well as the feedback provided by the EMR users, show the positive impact of the EMR technology on various aspects of patient care.

Overview Factors that Facilitate Deployment CPOE. Several factors supported the successful implementation of this project. Possibly the most important factor was the planning and evaluation carried out up-front by the CCHS project team. Communication and operational processes were established in advance of the introduction of the technology. This was carried out in a way that, on the one hand addressed the concerns of the staff that had reservations towards the technology, and on the other, established training and support facilities that assisted the transition of employees to the new workflow. Part of this effort was also the use of technology champions among physicians, as well as, a clear and transparent procedure for the development and introduction of *order sets*, which helped increase the utilization rate of the EMR system.

A critical success factor was the post deployment program which introduced additional devices and processes that were added to the EMR system, such as automated medication carts, personal notepad computers, and the online discharge procedure. The continued introduction of such services and devices will expand users' benefit from the technology, and provide further incentive for adoption.

Another critical factor which helped the deployment and adoption of the EMR system was the fact that Huron is a teaching hospital, with a large population of nursing students and resident physicians. The ability to mandate use of the EMR to students and residents (as well as other patient care staff), created additional impetus for adoption. The data showed that through the increased exposure to the technology, the overall opinion of mandated adopters regarding the EMR system was higher than that of physicians. EMR use by such a large portion of the employees served to bolster adoption from attending physicians who conduct a large portion of their practice from Huron Hospital.

The tools and options available to the project team to convince physicians to adopt are of an inclusive and facilitating nature. The project staff utilized every opportunity and tool available to promote and improve adoption by physicians. In conclusion, we can safely assume that ubiquitous adoption by all the physician staff can only be achieved through mandate, which Huron Hospital management does not have.

List of Publications and Products

None provided.