Grant Final Report

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Rural Iowa Redesign of Care Delivery with EHR Functions

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Abstract

Purpose: To evaluate the impact of implementing electronic health record (EHR) functions on patient care and organizational culture in rural healthcare hospital inpatient units, ambulatory care and two primary care clinics.

Scope: The partners implemented a comprehensive integrated EHR using computerized provider order entry (CPOE), interdisciplinary documentation, medication administration scanning, and clinical decision support (CDS) tools in a planned one-day "big-bang" approach.

Methods: A time-series design was used to evaluate effect on reported errors (medication errors); CMS/JCAHO quality measures; computerized ordering and decision support tools; emergency length of stay; and clinician/staff assessment of the implementation process and how the EHR has changed the quality and safety of patient care, communication among clinicians and patients; and daily work life.

Results: After thirty months the hospital and clinics have sustained a 70% CPOE rate with over 250 evidence-based order sets; 76 CDS rules; redesigned all patient-centered workflow processes to include quick registration, up-to-date medication lists, technical and content safety and error-prevention designs with required documentation. The partners improved timely antibiotic use and patient education CMS indicators while maintained others in the top quartile; maintained organizational engagement; and found no untoward consequences during the changes.

Key Words: implementation, electronic health record, evaluation

Final Report

Purpose

Objectives of Study

The objectives for this funded three-year, healthcare information technology implementation and evaluation project were to implement a comprehensive, integrated, EHR system using data standards, with computerized provider order entry (CPOE) and clinical decision support (CDS) tools, in several diverse, rural, northern Iowa health care settings (hospital inpatient units, ambulatory care, primary care and specialty clinics, home health, and hospice care) and to evaluate the effect of this EHR system on patient care and organizational culture. The project had four major goals:

1. To improve the quality of patient care and increase patient safety to the top quartile of JCAHO and CMS indicators.

2. To improve patient care workflow processes,

3. To enhance organizational culture and safety among the project partners, and

4. To generate significant organizational learning about the effectiveness of the EHR system and the implementation process.

The partners' first objective was to conduct the project evaluation initially using Mercy Medical Center-Clinton as the control site and Mercy Medical Center – North Iowa as the implementation (intervention) site. The evaluation was later expanded to include other Trinity Health hospitals that had implemented the EHR, and to compare that group with the hospitals in the system, which had not yet implemented this same type of technology and processes. This evaluation was possible because the same health system personnel, project management, and end-user resolution processes were used for health IT development and implementation across these system hospitals. The evaluation measurements for all hospitals within the system included: a) reported medical errors (including medication errors) and near misses; and b) Centers for Medicare and Medicaid Services (CMS) and Joint Commission (JCAHO) quality measures. The second objective was to conduct pre and post implementation evaluations at only the intervention rural referral hospital and two clinics which included: a) physician, nurse and clinician acceptance of EHR for daily processes; b) percent of pharmacist and physician responsiveness to adverse drug alerts (ADEs); c) physician specialty groups use of computerized provider order entry; d) the types of changes in design of service specific order sets (SSOS) for five diagnostic groups; e) the interdisciplinary processes supported by clinical decision support rules; f) emergency patient length of stay EHR tracking with physician electronic documentation and quick registration; and, g) clinician and super-user assessments of the implementation process and how the

electronic health record system has affected the quality and safety of patient care, daily work life, communication among physicians, other clinical staff, and patients.

Scope

Background Context and Settings

The project was led by Mercy Medical Center - North Iowa, a rural secondary referral center, in collaboration with Hospice of North Iowa, the Mason City Clinic, Mercy Medical Center - Clinton, Trinity Health, and the University of Iowa Department of Health Management and Policy. Mercy Medical Center - North Iowa (MMC-NI) is a non-profit community health care system with 18 wholly owned primary care clinics. MMC-NI is part of a regional network, Mercy Health Network – North Iowa, that is affiliated with nine critical access hospitals and 23 primary care clinics. MMC-NI offers comprehensive health care services for people throughout northern Iowa and southern Minnesota. As a major rural referral center and secondary level health care provider, MMC-NI has a workforce of more than 2,750 employees, 165 active medical staff members and 134 ancillary providers (nurse practitioners, physician assistants) that staff 193 acute, rehab and skilled beds, 41 clinics, homecare and hospice services. MMC-NI has 12,961 acute discharges, 1,122 newborn discharges, 34,341 emergency room visits, and about 585,000 outpatient visits per year. During this project period, the rural referral hospital implemented the Cerner PowerChart EHR (July 8, 2005) within a 24-hour period. Two of the owned clinics implemented the Cerner PowerChart Office EHR (February 26, 2007), and all other affiliated sites were trained to access the EHR's clinical data repository for patient diagnostic test results and hospitalization information when needed for follow-up. In addition, all active medical staff members and ancillary providers working within the hospital were trained on CPOE, service specific order sets (SSOS), and electronic documentation.

Mercy Medical Center – Clinton is a rural hospital within eastern Iowa which was identified as the control site hospital for comparison during this project period because they had not implemented the Cerner PowerChart EHR. Mercy Medical Center – Clinton completed implementation of the EHR, CPOE, and like clinical decision support on October 27, 2007. Both Mercy Medical Center – North Iowa and Mercy Medical Center – Clinton are hospital organizations that receive IT system services from Trinity Health.

Trinity Health is the fourth-largest Catholic Health system in the United States with operating revenues of $6.0 billion in 2006. It consists of 45,101 full-time equivalent employees and 7,346 active staff physicians, the majority of which are self-employed, community based, and have alternative hospital choices in most of the local markets. Trinity Health comprises 23 ministry organizations (health systems), encompassing 43 hospitals (28 owned, 15 managed), 379 outpatient clinics / facilities, numerous long-term care facilities, home health and hospice programs, and senior housing communities in seven states. Trinity Health coordinated development of a system-wide information technology strategy and implementation model. Trinity Health provides a clinical operation improvement (COI) department, system IT support center, integrated system and local IT services managed from corporate headquarters in Novi, Michigan. All hospital and clinic IT personnel within local sites are employed by and report to corporate IT and COI executive leadership. This integrated and centralized approach resulted in

standardization of core vendors and central management of software functions and future maintenance. Trinity's corporate IT structure was a key element in the success of this project.

The standardization of IT information and technology facilitated the development of a common phased implementation process across Trinity Health. The first phase of the clinical systems started in May 2001 and included installation of the central clinical data repository; interfaces for dictated reports, laboratory results; a results viewer (PowerChart); and seventeen rules for adverse drug events (ADE). This phase finished in January 2004 with owned hospitals and more recently expanded to affiliated critical access hospitals. MMC-NI activated this phase one in June 2001. The second phase included implementation of a new patient management system and the suite of clinical applications (interdisciplinary documentation, CPOE with evidence-based service specific order sets, integrated inpatient and home medication profile, a new pharmacy system, medication administration bar scanning, a new medical records system, an emergency department tracking system, a new radiology information system, drug alerts and clinical decision support expert rules). Other technology implemented within the healthcare system to support integration and standardization included an Enterprise Master Person Index (EMPI) system to establish unique patient identifiers for the enterprise-wide systems and remote access from office, home and other locations with web-access.

Trinity Health has developed preparation processes beginning 18-months prior to a planned "big bang" implementation. The preparation components included readiness assessments, common web-accessible project management database, pre and post measurement, quality improvement and change management, clinical workflow redesign, order set development, clinical decision support expert rule selection, organizational restructuring of roles and committees, scenario testing, and multiple training cycles. The preparations began by identifying one executive as accountable for the implementation process. For MMC-NI, the chief executive officer was accountable for this hospital to lead application of the Trinity Health implementation model. Unlike the highly recommended incremental implementations suggested by the American Medical Informatics Association, this project used a standardized process to implement the hospital and clinic EHRs, CPOE and CDS tools with a "big bang". The "big bang" approach consisted of bringing down all existing information systems, implementing the new technology and processes by inputting key patient data (existing inpatient and home medications, allergies and reactions, diet, active consult and patient care orders) into the new system within a 24-hour time period, and converting users to the new system for all clinical areas at the same time, over the course of a single Saturday. With an on-site control center and remote system staff to coordinate the steps as well as a large team of local and system trained super-users for all clinicians and support staff, a "big bang" approach was used to transform from encounter-specific paper-based medical records to longitudinal electronic health records.

The preparations and implementation included collaborative teamwork as staff from other hospitals in the Trinity System assist each other during the "big bang" cutover from paper and old technology to implementation of the new health information technology and redesigned workflow processes. At MMC-NI's activation was assisted by staff from Trinity Health's corporate office, other hospitals that had previously activated the EHR and hospitals that were ready to implement within the next one or two years. This support team included all disciplines and demonstrated a hands-on interactive learning approach such as "see one, do one, teach one." With this Trinity Health approach, all hospitals in the system will transition to the standard health information technology during the 2008 - 2009 period.

This study looked at how that system-wide strategy and implementation model was used at MMC-NI, and how the care delivery system was redesigned using an EHR. The research team presents this final report of the evaluation of this successful "big bang" implementation of many applications associated with the EHR. An informatics physician as the principal investigator and informatics nurse co-principal investigator from Trinity Health managed the research team. The team was supported by the partnership with The University of Iowa investigators and research assistants from the Department of Health Management and Policy and College of Nursing. Project collaborators at the University of Iowa and the University of Missouri-Columbia conducted data analysis and evaluation.

Key Partner Participants

The scope of this project involved many participants over the course of the preparations, implementation and evaluation. The team was consistent throughout the three-years of the grant, although the executive leadership of Trinity Health and the chief medical officer and chief nurse officer at Mercy Medical Center – North Iowa changed. These organizational changes were in process during the months preceding the implementation and did not impact the final outcomes of this project. Many physicians, clinicians and staff from Mercy Medical Center – North Iowa, Trinity Health data centers and services, and the many hospitals and clinics participated within this project in some manner to support the Health IT design, redesign of processes, the preparations and implementation of the EHR in hospital and clinics.

Principal investigator. Dr. Donald Crandall, a physician and chief informatics officer and now clinical informatics consultant for Trinity Health was the principal investigator for this study. Dr. Crandall participated in decisions to standardize the health information technology and knowledge databases that were acquisitioned and used for the electronic health record and clinical decision support tools at the health system level. Dr. Crandall directed the grant activities and supported dissemination strategies.

MMC-NI staff. Chief Executive Officer, James Fitzpatrick, was the accountable executive for the hospital implementation; the Mercy Heath Network – North Iowa Executive, Doug Morse, was the accountable executive for the clinic implementations; the Director of Information Systems, Randy Haskins, managed the technology infrastructure for the hospitals and clinics; the Director of the Residency Program and Clinic, Dr. Scott Henderson, a physician instrumental in the steps to implement the primary care clinics; and the Clinical Informatics Manager, Tammy Schwichtenberg, a nurse managed the day-to-day implementation and ongoing informatics improvements for the hospitals and clinics. She manages the staff of nurses who help with the hospital departments, the clinics, and the affiliated critical access hospitals to support the local preparation, implementation and sustaining the EHR system.

Trinity health. Dr. Jane Brokel, a nurse and director of clinical transformation for Trinity Health and now assistant professor at the University of Iowa was the co-principal investigator. Dr. Brokel participated in education and preparation steps to redesign patient-centered workflows, development of order sets and clinical decision support rules for Trinity Health at the system level and now teaches informatics for The University of Iowa and consults on

management and evaluation of CDS expert rules for Trinity Health. Dr. Brokel managed day-to-day grant affairs and evaluated the EHR changes, order sets and clinical decision support rules.

The university of Iowa. Dr. Douglas Wakefield, professor and health management and policy researcher at the University of Iowa and now at the University of Missouri-Columbia provided the partners with the evaluation research design for this study. Dr. Wakefield evaluated the organizational culture, CPOE, verbal orders, and work life. Dr. Marcia M. Ward, professor of health management and policy at the University of Iowa provided the partners with the staff for statistical analysis and evaluated the Emergency room length of stay, CMS/JCAHO quality indicators, ADEs, medical errors and near misses.

Other partners added. This team of investigators added support from Dr. Jonathan Halbesleben, assistant professor at the University of Missouri-Columbia and now at the University of Wisconsin. Dr. Halbesleben completed the psychometric testing for a survey tool used within the grant activities.

Project Occurrences and Common Processes

Hospital EHR preparations. This project began with the process for "Operational Build of Content and Structure" which was underway during the first six months (9/30/04 to 4/2005). The team of investigators began to collect information to evaluate any prior and current preparation steps. Mercy Medical Center – North Iowa (hospital) had just completed initial work sessions to design clinician workflows for patient care and were ready to engage in identifying the content used for the EHR. This content included designing a number of order sets for CPOE, selecting or designing new CPOE orders, clinical rules for alerts, reminders, messages, orderable requests, and selecting the clinical documentation forms to use within the EHR components. The preparation steps included review of existing system-wide standardized electronic forms, orders, pharmacy drug formulary, evidence-based order sets, and aligning all hospital and clinic positions to security levels for EHR access. The design included very few additional needs for changes in the standard system-wide electronic forms and orders. Most of the rural referral hospitals request for design and build was around the development of a pharmacy drug formulary and the evidence-based designed order sets for each service (i.e. orthopedics). The assignment of employees and physicians to existing approved levels of security for roles was coordinated by the informatics nurse, who worked with each manager to ensure correct access to the EHR was provided for the employee's responsibilities. This was an improvement over previous steps to assign correct roles by managers alone.

After the hospital finished identifying content, the process for Health IT and EHR Operational Testing and Training began in the six months before implementation (1/2005 to 7/7/2005). At this time the super-users were trained and asked to participate in testing the workflows with the technology. The team of investigators participated in meetings and reviewed implementation project reports that reported on the progress in testing patient scenarios and completing cycles of employee and physician training. The clinician super users were involved in testing a number of redesigned workflow processes and procedures with technology and reported their acceptance level. Usability testing involves the assessment of ergonomic and cognitive criteria as identified by Bastein and Scapin (1993) to determine level of acceptance with application prompting, readability, immediacy of feedback, grouping of information and fields, handling of errors, consistency of

design, flexibility, and load on the user (Brender, 2006). The nurses coordinating the testing identified and logged each unacceptable step as an issue related to the technology applications and devices, an issue with the changes to role responsibilities, or a suggested alteration needed for workflow processes and procedures. When the issues were resolved and testing met acceptable levels four months prior to activation, the training process began for all clinicians to learn the new redesigned processes. The trainers and super users provided direct education to all professional disciplines in four cycles and encouraged indirect practice time for each discipline. While the physician training process included flexible scheduled training and just-in-time training during the first week of implementation. The investigators were interested in the pre expectations and the post implementation experiences to evaluate the training process and the implementation process.

Hospital EHR implementation. The hospital activated the EHR on July 8, 2005 and on-site post implementation support was available though the thirtieth of the month. The team of investigators participated in progress meetings with the hospital and a weeklong post-implementation evaluation at five weeks post implementation conducted by the Trinity Health team of analysts that support the EHR. The reports from these meetings describe the positive and negative issues related to the hospital's cutover process during the activation, the positive and negative issues related to the technology, the issues related to the management and support roles, and workflow processes and procedures in the care delivery identified by the super-users. The Command Center operated with 24-hour local support for the first seven days and reduced to daytime (12-hour) support in the second week with remote resolution center support.

Clinic EHR preparation and implementation. The outpatient clinic EHR (Cerner PowerChart Office) preparation process began following the hospital EHR implementation. Clinic issues were identified during the post-implementation evaluation of the hospital EHR. The research team documents the clinic implementation project outlining the formation, progress, and summation steps during monthly research team meetings because this process was never completed elsewhere. The first steps were to align resources (people, technology, the scope of applications to be used) and to conduct assessments of readiness for two clinics. This included identifying three critical people, the physician and nurse champions along with an accountable executive for MMC-NI; finding vendor technology to solve the registration and scheduling processes that were disrupted by the hospital implementation; and affirming the applications that will be used to support most every workflow process for a patient phone call and visit to the clinic. The initiation of an EHR to collect pre-assessment and patient history was critical.

The second step identified current workflow processes that were problematic following the implementation of the hospital's health information technology in July 2005. Following the hospital's implementation, the clinic staff were required to complete two registration processes within two applications for each clinic patient to manage both professional billing and facility billing for each clinic visit. The clinic implementations were delayed to search for an appropriate solution to address the duplicative registration process that became costly after the hospital implementation. Trinity Health, Mercy Clinics and two other Trinity Health organizations implementing Cerner PowerChart Office for clinics collaborated to identify a sustainable solution. This solution-finding process extended the preparation time approximately six months. A Trinity System executive team decided to standardize EHR applications for all clinics in the health system to use the Cerner registration and scheduling applications with the Cerner PowerChart

Office EHR and interface with the IDX Group Practice Management System and the McKesson HealthQuest patient management and registration system used for hospitals.

Once the decision was made to standardize EHR applications and to interface group practice management applications for professional billing, the Mercy Clinics physician and nurse champions collaborated with informaticians and Trinity Health project management staff to begin the third step of redesigning 23 patient-centered workflow processes for scheduling of patients, registration, clinic visits and phone calls, prescribing, and clinic billing processes.

The fourth step was to build interfaces between three health IT vendor technologies (Cerner PowerChart Office EHR, the IDX Group Practice Management System and the McKesson HealthQuest patient management and registration system). Other steps included the designing of physician templates for clinic visit notes, documentation forms, and identifying clinical decision support expert rules for the EHR. The fifth step began in the fall of 2006 with testing the interfaces, the clinical and patient management workflows and technology, and the training of all clinic personnel two months before the scheduled implementation. The initial acceptance level was low for the registration workflows, which resulted in a delay to find and implement solutions for handling multiple insurances that required updated designs with the registration application. During this delay, the clinic physicians were able to generate additional physician templates for documenting patient visits for obstetrics, newborns, well-child, and health maintenance.

The final step was the day of activation for the registration and scheduling applications and processes (Feb. 3, 2007), and clinical EHR and processes (Feb. 24, 2007). Local super-users including two clinic nurses, physician champion, and several registration staff and IT analysts on site supported this final step. A remote health system Command Center was in place to address the technical issues from the two clinics. The patient's electronic records were prepared the day before the visit and routine visits were scheduled during the initial days of implementation. The nurses who supported the redesign of workflows and Dr. Henderson were key support persons with the implementation. Most of the residents were comfortable with the technology and were able to use the system forms and notes as time permitted. In the first month post-evaluation five physician templates for notes were requested to improve electronic documentation. In subsequent months the templates became available for use. The clinic physicians became integral in the designing of templates for high-volume visit types such as musculoskeletal upper and lower extremity injuries.

In summary, the clinic implementation process provided a description of the necessary preparation in structures (technology, administration, staffing pattern), roles (lead change agent roles, application role, super-users, time involvement of clinic staff including physicians, nurses, medical technicians, and others), workflow processes (workflows and the flow chart differences) for not only the two clinic sites but also other network and system clinics. These reports describe the milestones specific to a clinic implementation and the methodological steps used to standardize a clinic implementation to minimize the critical impact for a small rural clinic. The redesigned patient-centered workflow processes for clinics, the training and testing process, and the cutover process for clinics to prepare for patient visits are reusable steps for other clinic implementations. Overall, the identification of key individuals, the strategic milestones, and stepwise tasks for a planned implementation became the implementation style that has been improved and replicated at subsequent hospital and clinic implementations.

Methods

Study Design

An interrupted time series with a nonequivalent control group design was used for several components of this evaluation. The EHR/CPOE implementation was carried out at MMC- NI and two associated clinics, and compared with the control being Mercy Medical Center–Clinton (MMC-C) in Clinton, Iowa. Both hospitals are rural referral hospitals owned by Trinity Health system. Data comparisons were made across two consecutive periods aligned to coincide with the MMC-NI implementation phases: EHR/CPOE Pre-Implementation Phase (7/8/03-7/7/05), and EHR/CPOE Post Implementation Phase (7/9/05-9/1/07). July 8, 2005 was the "Go-Live" date for the hospital and February 24, 2007 for the clinics at which time there was a total transition from the Pre-Implementation to Post-Implementation Phase. The Mercy Medical Center – North Iowa Institutional Review Board evaluated the subject/organization protections through review of the annual progress reports and quarterly reports to learn about the progress and evaluations completed and planned for the evaluation study during the three years.

Data Sources/Collection

The data sources were purposely designed to take advantage of the wealth of secondary patient management and organizational data already collected to measure quality and safety at MMC-NI, MMC-C and by Trinity Health. MMC-NI was participating in the CMS-sponsored Premier Hospital Quality Incentive Demonstration Project and was already collecting indicator data for several conditions. This ongoing data collection effort permitted us to evaluate levels of performance for a year before and after EHR/CPOE implementation. Moreover, because CMS data were collected throughout Trinity Health, we were able to compare hospitals with and without an EHR throughout the system. Another secondary data set included the Trinity Health system-wide PEERS adverse events and error reporting system. In cases where ongoing data collection did not include the required evaluation data, we implemented primary data collection for evaluation purposes related to organizational and staff perceptions and experiences, and new indicators specific to the EHR adoption and use such as CPOE rates, verbal orders, and electronic notes per visit.

Interventions

The electronic health record was a Cerner PowerChart for hospital and PowerChart Office for clinics. The architecture uses Oracle database management software with Microsoft Visual C++, Basic and Foundation Classes. The hospital EHR included the following department applications, Cerner RadNet radiology, PharmNet pharmacy, and FirstNet emergency tracking which were integrated with the clinical data repository and Cerner PowerChart. Bar scan medication administration was an interdisciplinary application but primarily performed by the largest group of healthcare professionals, nurses. The clinical EHR included the following applications: a provider inbox, scheduling, registration, easy script prescription writing, PowerNote physician documentation, problem list, allergy list, PowerForms for clinical documentation, health

maintenance and super bill designs. Clinical decision support tools included applications such as 1) Multum database alerts with CPOE and PharmNet ordering; 2) Medical record publishing; 3) Discern Expert clinical decision support rules (CDSR) with Adverse Drug Events and executable knowledge models for triggering actions and decisions from patterns of available data; 4) Discern Explorer reports for concurrent reports; 5) Zynx Health Knowledge Executable Manager with evidence-based templates for designing disease-specific order sets for service areas (SSOS). Other applications included McKesson HealthQuest hospital registration application, Cerner clinic registration and scheduling application and Peoplesoft financial management system.

Measures

The evaluation was organized around four dimensions. 1) The investigators used interviews and documents to describe the impact of leadership, strategies and tactics used, and the effectiveness and response to problems. The investigators completed psychometric tests using confirmatory factors analysis for a newly designed clinician survey to measure the expectations before and the experiences after implementation. The survey instrument had excellent fit with post experiences and weaker fits with pre expectations for 7 factors: Provider-Patient Communication, Inter-Provider Communication, Inter-Organization Communication, Work life Change, Improved Care, Implementation Strategy, and Quality. Investigators compared four consecutive annual Gallup Engagement Scores for impact of changes. 2) The biostatistician received secondary data from the health system to compare 17 adverse drug events (ADEs) alerts, potential errors and event reporting system (PEERS), and the CMS/ JCAHO indicators for heart failure, pneumonia, acute myocardial infarction, hip and knee joint replacement procedures and coronary artery bypass graft procedures over three time periods. 3) The investigators assess the changes to workflow measuring emergency room length of stay pre and post implementation, the hospital's percent use of verbal orders, the physician CPOE rates per service area. The physician champion measured the clinic PowerNote documentation usage by residents and faculty, the percent of prescriptions entered and faxed to pharmacies, and the percent of updated problem lists and medication lists by physicians and the nurses. 4) The investigators assessed the types of changes to service specific order sets (SSOS), types of changes to EHR applications and clinical decision support rules (CDSR).

Limitations

One limitation was the inability to use an extended data warehouse during the 3-year grant period. The extended data warehouse had been delayed and is now realized at the close of the grant in October 2007. Due to this delay, the research team was limited in assessing how the hospital used the data warehouse as technology to report on quality. Likewise a delay in the EHR implementation in the ambulatory clinic setting limited evaluation efforts in this area.

Results

Principle Findings and Outcomes

The project findings are presented for the four major goals with the EHR implementations**.** The findings are the result of using multiple assessment approaches. The primary evaluation components are described below along with some preliminary and final research findings at this time. While data collection is complete, analyses and interpretation of results are ongoing with the near-term goal of producing a number of peer-reviewed publications as part of our dissemination plan.

Overall evaluation of the EHR activation process. The adoption and activation of the patient management registration, clinic scheduling, hospital finance management, hospital coding of encounters, pharmacy, radiology, emergency tracking applications, and the hospital and clinic EHR applications and processes were uneventful. There were no significant errors or major deficits in redesigns of processes, order sets or technology down time.

The engagement and adoption of the physicians and health disciplines was evident in the early hours of the activation on July 8th in the emergency room. Subsequent departments and nursing units followed, with widespread adoption and use of the EHR. A big bang-like change requires a large number of support staff to meet the initial needs of just-in-time training. Despite the two to four-cycles of training for clinical and support staff, the training sessions cannot possibly cover all of the functionality that an operating EHR system provides. The ample use of departmental and physician support super users is necessary to engage and supply just-in-time teaching of functions necessary to support the complex clinical processes that involve a wide variety of patient types and an individual patient's situation. The command center was set up for the go-live on July 6th with cut-over scheduled activities starting July 7$^{th.}$ Friday evening events begin with capturing existing data on a census of over 160 inpatients. The old technology is literally turned off and the hospital goes into downtime procedures while the new HIT is backfilled with patient data content from old systems. This requires both electronic and manual steps and a series of verifications and validations that are also electronic and manual to ensure the safety and quality of data for new health IT to be actively used. Through the evening, night and early morning hours the processing is occurring to afford the Emergency Room to be the first in line to activate using the new EHR. This happened by 10:26 am July 8$^{th.}$ All subsequent units followed within the hours after until midnight when all units and departments were live using the EHR. A large staff of super-users were on-site across the care areas for support and just-in-time education. The command center operated in a 24 hour-7day week mode for 10 days and began to reduce hours to 13-16 hours a day until dismantled on day 15 and the 24-hour health system resolution center took over all calls for support. The Trinity Health system EHR has maintained an average 99.96% cumulative up time during the past calendar year.

Evaluation of the Effect of EHR Implementation on Patient Care Quality & Safety

Goal 1. To improve the quality of patient care and increase patient safety to be in the top statistical division of JCAHO and CMS indicators.

CMS indicators. A goal of the project and of the EHR implementation at Mercy Medical Center – North Iowa was to achieve top-quartile performance on the CMS/JCAHO performance indicators. This was achieved. However, a simple look at the performance levels does not permit the performance to be attributed to the EHR implementation, because performance was nearly 100% on several indicators prior to implementation.

However, we were interested in examining further whether EHR implementation had any effect on these performance indicators. Thus, we took advantage of the situation that nine Trinity Health hospitals have implemented EHR over the past three years. We examined a time series of data for each intervention hospital, centered around the time when each experienced "Go-Live". Of the 14 CMS/JCAHO indicators that had sufficient data to analyze, the proportion of defect was analyzed using Proportion Defective control charts (p-charts). These charts reveal that 50% of these indicators show recognizable trends in reduced defects and/or variation after EHR implementation. The seven improved indicators are: AMI 4 - Adult Smoking Cessation Advice; HF 4 - Adult Smoking Cessation Advice; PN 4 - Adult Smoking Cessation Advice; HF 1 - Discharge Instructions; HF 2 - LVF Assessment; PN 2 - Pneumococcal Vaccination Status; and PN 5 - Pneumonia Initial Antibiotics Received Within 4 Hours of Arrival.

Many of the CMS/JCAHO indicators that did not show visible trends of improvement were limited by a "floor" effect, thus there was not much opportunity to substantially improve these processes in the post-implementation period. A total of five "floor effect" measures were all AMI measures that show mean defect rates of < 9% over the entire 18 month period: AMI 1 - Aspirin at Arrival; AMI 2 - Aspirin Prescribed at Discharge; AMI 3 - ACE Inhibitor/ARB for LVSD; AMI 5 - Beta Blocker Prescribed at Discharge; and AMI 6 - Beta Blocker at Arrival. However, within these 5 "floor effect" measures there is evidence of intervention efficacy as there were 3 months in which the defect rates were reduced to zero – once for AMI 2 - Aspirin Prescribed at Discharge, and twice for AMI 5 - Beta Blocker Prescribed at Discharge. In the two remaining measures, HF 3 - ACE Inhibitor/ARB for LVSD and PN 3 - Blood Culture Performed in ER Before 1st Antibiotic Received, there were no discernable trends in regard to reductions in defects and/or variation. Using these same indicators, overall rates of process performance defects were analyzed for the 9 hospitals that had implemented the Project Genesis Clinical and Revenue Cycle Systems (Cerner) over a period of 18 months. Overall system rates of defects were calculated by centering each of the 9 hospitals' monthly defect rates over 10 pre-implementation and 8 post-implementation periods. Our statistical analysis of these data are ongoing using a set of matched hospitals that have not yet implemented EHR as controls. Initial results indicate that the intervention hospitals showed a change after "Go-Live" that was not seen in the control hospitals. The changes took various forms; some indicators showed a sizable jump immediately after "Go-Live", other indicators showed a change in slope so that improvement occurred over time.

Evaluation of Changes in Patient Care Workflow Processes

Goal 2. To improve patient care workflow processes.

Redesigned workflows. Both department-level workflow processes (e.g. pharmacy, nursing) and patient-centered workflow processes (e.g. emergency) were used to redesign clinician's use of HIT with patient care services. The findings from redesigned workflow processes involve the

use of the EHR's applications (e.g. electronic orders and documentation), clinical decision support tools (e.g. SSOS, CDS rules, Multum alerts), and other hospital activities requiring paper-based documents (e.g. informed consents; EKGs) that are impacted due to accessibility of non-EHR patient information. Only the Emergency Room used the patient-centered workflows whereas other services used department workflows. Patient-centered workflows included all interdisciplinary processes associated with a type of patient services whereas department workflows addressed only one department's use of the technology. The patient-centered workflows required very few changes post implementation, whereas the department workflow processes required corrections and sometimes inclusion of missed functions that often involved processes not directly using the EHR. This rework of workflow functions took place within the first 3 months of implementation. The clinic workflows were constructed to include the patient-centered approach that displays the interaction of all disciplines. The hospitals changed to using cross-functional flowcharts with a Microsoft Visio application that included the patient, all involved clinical disciplines and support roles.

CPOE use by providers. The use of CPOE using Cerner PowerOrders was initiated on the first day of activation. The initial (July 2005) physician CPOE rate (physician entered orders divided by all orders including verbal/phone orders and written orders) was 69% in the hospital overall and 88% in the emergency center. Two years later, the overall hospital CPOE rate was 70.2% and the emergency physician rate continued over 85%. Interestingly, the relatively little change in the percentages of CPOE vs. verbal/phone orders made by physicians following CPOE implementation suggests an unexpected stability in physician CPOE use patterns. Additional analysis of paper-based verbal/phone order content highlighted the great variation in the complexity of the orders being communicated. Using the post-CPOE implementation capacity to capture all verbal/phone pharmacy orders, we were also able to develop new approaches to screening these orders for the presence of commonly confusing medication and high alert medications. Our analysis also found that when physicians used the CPOE, developed a list of favorite orders and used service specific order sets (SSOS), the physicians maintained or improved their respective CPOE rates over time. Overall, we found the physicians appreciated the just-in-time educational mechanisms when the EHR and all applications were implemented with the big-bang implementation, but recommended additional education post-implementation in brief sessions. Additional education was provided in specific departments and CPOE use rates increased for those providers after attention was given to their needs.

ED length of stay. Although not planned in the original proposal, Trinity Health requested that the investigators evaluate the length of stay (LOS) for emergency patients. Pre-implementation log files were analyzed for one week each quarter (October 2004, January 2005, and April 2005) before the July 2005 Go-Live and post-implementation log files were analyzed for one week each quarter (July 2005, October 2005, and January 2006) after Go-Live. The pre-implementation LOS averaged 117 minutes and the post-implementation LOS averaged 134 minutes, an increase of 17 minutes on average, which was highly significant statistically ($p<.0001$). The average LOS over the three pre-implementation quarters was quite consistent. The average LOS showed some trend toward decreasing LOS over the three quarters post-implementation. Analysis of differences across weekdays/weekends and by disposition showed the same general pattern, indicating that the increase of 17 minutes on average

was consistent across conditions and not related to day of the week, time of day, or disposition of the patient. Noteworthy was a substantial decrease in variability post-implementation.

A redesigned Emergency Room workflow was implemented with several technologies that included the Cerner FirstNet tracking technology with Cerner PowerChart which permitted visual knowledge of when patient diagnostic results were returned; computerized physician order entry (CPOE) using Cerner PowerOrders which permitted ER physicians to enter 85% of the patient orders; physician documentation using 45 templates with Cerner PowerNotes technology permitted the compiling of patient summaries that were readily accessible on the patient floors and the external clinics who had office and remote access to the EHR; interdisciplinary documentation with electronic forms that permitted real-time recording of assessments for view by physicians and others; and finally, the steps to permit a quick registration to establish the patient record prior to patient care and completion of bedside registration with McKesson HealthQuest. EHR-related process changes, enabled by the EHR technology, have probably decreased ED LOS to some extent. However, a change in the registration process is likely contributing to an apparent increase in LOS. With EHR function, patients are registered immediately and a time stamp is initiated upon arrival in the ED. It is likely that the time stamp was delayed with the registration procedures used prior to EHR implementation.

Redesign of standing order sets. The initial list of needed order sets to prepare the hospital for implementation was identified at 350. The initial service specific order set (SSOS) strategy was to allow site-specific order sets. The sharing of SSOSs across sites is the ideal because the creation, confirmation and maintenance of SSOSs remain a challenge to keep up-to-date with evidence-based medicine and is a time-consuming process. Trinity Health processes include an intensive pre-implementation build activity during which each of the SSOSs is reviewed, edited and accepted through a seven-step preparation process before activation. This intensive review reduced from 350 to 250 the total number of service specific order sets and nested order sets approved for the implementation in July 2005. Part of the editing process changed individual orders to nested order sets within a SSOS. The approved SSOSs were organized under services areas of: anesthesia, behavioral medicine, cardiology, cardiothoracic, critical care, EENT (ears, eye, nose and throat), medicine, neurology/neurosurgery, newborn/pediatrics, obstetrics/gynecology, oncology, orthopedics, radiology, special procedures, surgery, and vascular services. The research team analyzed the types of changes for five diagnoses: pneumonia, chest pain with AMI, CHF, coronary artery bypass graft, hip and knee replacement surgery. After the first year, few individual orders were deleted and several individual orders became nested orders sets that were added to SSOS. The Trinity Health sharing of SSOSs across sites is moving forward; for example, in year two, the Pneumonia SSOS became a system-wide SSOS. Prior to activation only one nested order set was shared across hospitals.

Design of clinical decision support rules. A total of 56 Clinical Decision Support Rules (CDSR) were designed for use with the hospital EHR and 17 CDSRs were designed for the clinics in the intervention site. The CDSRs were used to remind, send a message, or order follow-up assessments and interventions to be documented in support of specific workflow processes in the hospital. For each service area, clinical decision support rules were developed to support workflow processes for use in the EHR and CPOE system (See Table 1). Preliminary analysis was completed after three months to evaluate the short-term consistency of operation.

All CDRS appeared to operate but consistency could not be assured because report method interfered with EHR response times. Further studies are planned to evaluate the validity, reliability and effectiveness of each rule.

Table 1: Workflow Processes Supported by Clinical Decision Support Rules

Workflow Process	CDS	Workflow Process	CDS	Workflow Process	CDS
Dietitian services	7	Physician services	3	Critical care	1
Interdisciplinary Inpatient care	7	Maternal-child care	3	Social Worker	1
Newborn/NICU care	5	Diagnostic radiology	3	Rehab services	1
Pharmacy services	5	Pediatric care	3	Diabetic educator	1
Nursing services	5	Spiritual care	2	Respiratory care	1
Behavioral healthcare	4	Infection control	2		

Evaluation of Changes in Organizational Culture of Safety

Goal 3. To enhance organizational culture and safety among the project partners.

Information systems expectations and experiences (I-SEE) survey tool. The expectations and experiences of clinicians were assessed using an instrument developed during the course of this project that we call the Information Systems Expectations and Experiences (I-SEE) survey tool. The instrument assesses respondents' perceptions related to communication changes, changes in selected work behaviors, perceptions of the implementation strategy, and the impact on quality of patient care. The instrument can be used to assess perceptions before and after implementation of an EHR, CPOE, or other clinical information systems. The initial validation sample included registered nurses at Mercy Medical Center – North Iowa. Samples of registered nurses at three other Trinity Health hospitals were used to cross-validate the factor structure of the scale. Basic item analysis, confirmatory factor analysis, cross-validation factors analyses, and reliability analysis were used to assess the psychometric properties of the scale. Five factors for clinical care delivery within the organization were identified: Provider-Patient Communication, Inter-Provider Communication, Inter-Organization Communication, Work life Change, Improved Care, Implementation Strategy, and Quality and two other factors measured the implementation process for Support and Resources and Patient Care Safety. Confirmatory factor analysis generally supported the a priori factor structure for both expectations and experiences regarding the clinical information system. The consistency of the fit to the factor models was also high across the cross-validation samples. The scales demonstrated acceptable internal consistency in all the samples. These psychometric analyses suggest that the measure of clinical information systems expectations and experiences offers a valid and reliable tool for assessing the perceived impact of new clinical technology on work process and outcomes. This instrument can be useful before and after technology implementation by assisting in the identification of staff perceptions and concerns, thus allowing for targeted interventions to address these issues.

The factors were scored favorable prior to implementation and for the most part remained favorable though the expectations were often higher than actual experiences at six months and twelve months later. Based on this model the higher expectations predicted favorable experiences in adoption of the technology that which impacted one or more of the seven factors. This survey offers researchers and informatics professionals a tool to test these predictions with future informatics studies and implementations. In follow-up, the I-SEE survey has been provided to other health system hospitals, critical access hospitals, academic medical center and community hospital for use as these sites are preparing to use the tool prior to their implementations to determine adoption with three different vendor health information technologies.

Super user survey tool. An additional survey instrument was developed to measure the perceptions of the Super Users at Mercy Medical Center – North Iowa. The survey items asked Super Users about the time they spent on their activities and their attitudes about the Super User role. To examine the effect of the role of Super Users on employee attitudes during EHR implementation, data were matched between the Super User survey items and the I-SEE responses for employees at their unit or department. Analyses indicated that the time spent in the role of Super User was most consistently associated with positive employee attitudes; Super Users' perceptions about their qualifications and others also predicted some employee attitudes, particularly about care outcomes and perceptions about implementation of the EHR systems. The findings suggest that Super Users may play a significant role in shaping the experiences of employees following EHR implementation.

Evaluation of Organizational Learning about the Effectiveness of the EHR System and the Implementation Process

Goal 4. To generate significant organizational learning about the effectiveness of the EHR system and the implementation process.

Significant organizational learning occurred in both the hospital EHR implementation and in the clinic EHR implementation. The implementation of EHR at Mercy Medical Center – North Iowa cannot be viewed without understanding the comprehensive planning process developed by Trinity Health which has evolved over the five hospital EHR implementations and multiple clinic EHR implementations that preceded the implementation at this site.

Organization learning from the hospital EHR implementation. As part of its standard practice, a Trinity Health team of analysts that support the EHR conducted a weeklong post-implementation evaluation at five weeks after "Go-Live". The team of research investigators participated in this evaluation and also in ongoing progress meetings at the hospital. The reports from these evaluations and meetings describe the positive and negative issues related to the hospital's cutover process during the activation, the positive and negative issues related to the technology, the positive and negative issues related to the management and support roles, and workflow processes and procedures in the care delivery areas raised by the super-users. At the weeklong post-implementation evaluation, interviews with physicians included all specialty areas and led to a top ten list of needs. The physician interviews disclosed a need for ongoing education in focused areas such as using the Inbox for editing dictated preliminary reports for

finalizing, updating the medication profile and adding prescriptions and a method to disseminate this education. In preparation for the evaluation on patient care processes, the clinical nurse managers had been asked to identify any problematic processes. At the post-implementation evaluation, the clinical nurse leaders and managers disclosed what the staff perceived as problematic processes and how these processes could be improved. The needs identified by the physicians and clinical nurse leaders and managers became part of the organizational learning at Mercy Medical Center – North Iowa and also at Trinity Health. Actions to address specific needs were implemented at Mercy Medical Center – North Iowa in the months after implementation. Needs that spanned multiple hospitals were taken back to Trinity Health and addressed in a system-wide enhancement of the pre-implementation build process. This comprehensive planning process includes significant redesign of care processes that continues to evolve with each new site "Go-Live".

Organizational learning from the clinic implementation. Like the hospital EHR implementation, the EHR implementation in outpatient clinics has been an evolving learning process throughout Trinity Health. At Mercy Medical Center – North Iowa, the outpatient clinic EHR preparation process had to begin prior to the hospital EHR implementation because the review of future hospital processes identified a need for registration of all clinic patients into the hospital's new registration application to process a patient's account. The inability of processing the patient's bill after a clinic visit was a recorded issue. An important learning from review of hospital future processes is to understand and address the consequences to other health care settings. The problematic consequence began following the implementation of the hospital's health information technology in July 2005 where each clinic patient was registered into the IDX and HealthQuest vendor registration systems. This workflow required hiring additional staff solution to address the duplicative registration process that became costly after the hospital implementation. Trinity Health, Mercy Clinics and two other Trinity Health organizations implementing Cerner PowerChart Office for clinics collaborated to identify a lasting solution. A month before the hospital Go-live date, an executive team decided to standardize EHR applications for all clinics in the health system to use the Cerner registration and scheduling applications with the Cerner PowerChart Office EHR and interface with the IDX Group Practice Management System and the McKesson HealthQuest patient management and registration system used for hospitals. A delay resulted during which the interface solutions were developed and technology purchased. The initial build was tested 15 months later but not without difficulties because of the inconsistencies among the large number of insurance companies data needs which required data fields for the three vendor systems to either collect or accept the same registration information to facilitate both professional and facility billing processes.

As part of this clinic implementation process, a description of the preparation necessary was formalized for clinic sites. The outcome was to establish a standard process with milestones and tasks that lead to a successful implementation of clinic EHR implementation. Seven major milestones were established and included the following: 1) Statement of Work approved; 2) Process Workflow Design completed for clinical visits, scheduling, registration and finance management; 3) HIT System Build completed following decisions on workflow processes to interface biomedical and other data and to integrate evidence-based content, CDS rules, electronic forms and notes for documentation; 4) User Acceptance Testing completed with established scenarios using future patient-centered workflows and management workflows; 5) End-User Training; 6) Go-Live Activation; and, 7) Post-Go-Live Debriefings and Learning. Each

milestone had critical tasks to complete prior to progression. In the fourth milestone, when the user does not accept the scenario tested, the issues identified in the workflow were recorded for immediate follow-through and decisive resolution as seen with the registration process. The date for Go-Live was delayed 4 months to obtain vendor solutions and improve the future redesigned workflow processes. In the final milestone, a clear transition of HIT support is distributed into existing support structures such as help-desks, staff responsible for EHR, Scheduling, and Registration upkeep. Locally, new roles and responsibilities within the Informatics and Practice Department facilitated ongoing weekly changes for hospital and clinics with technology, but more often with new content or the removal of discontinued or recalled content (e.g. evidence-based practices changes, insurance companies, etc).

In summary, these seven milestones were established to provide a framework for clinic implementation, to define the methodological steps used to standardize and ease the burden of a clinic implementation, and to minimize the critical impact for a small rural clinic. The clinic nurse was instrumental in leading the workflow redesign process for clinics, the training and testing process for clinics, and the cutover process for clinics to prepare for patient visits. The physician champion and nurse were the support roles to implement an EHR within the clinics. Additionally, the physician and nurse from the clinic helped integrate the clinic office practice with the hospital processes. These common processes and stepwise tasks within a planned implementation became the implementation style that has been improved and replicated at subsequent hospital and clinic implementations.

Impact assessments were conducted for critical workflow processes. One of the critical measures included the reduction of transcription costs used to document clinic visits. This measure is directly associated with the indicators for the number of electronically captured physician notes per clinic visit per resident/faculty physician/primary care physician. As the use of EHR templates for clinic notes increase, the outcome was for the electronic capture of notes/visit/physician to double. Following initial implementation, seven clinical note templates (muscular-skeletal upper and lower extremities, back pain, abdominal pain, well-child pediatrics, psychiatric health, obstetrics and well-baby newborn) were requested to meet the need for the most prevalent patient visit types. In assessments of scheduling, clinic end-users reported very fluent clinical workflow post implementation. In assessments of registration, clinic end-users reported issues with a number of insurance companies' data capture and use. These were corrected and two additional clinics (Buffalo Center and Sheffield) have successfully implemented the registration and scheduling applications in September 2007.

Discussion

Seven milestones in the preparation processes were met before the big-bang activation of the EHR in July 2005. Some practical steps within each milestone offer lessons in achieving this success. First, assessing the physician community's awareness of the health IT was critical eight months prior to the Go-Live date. Acknowledging that most physicians favored a hybrid EHR to meet each specialty's need, clinical executive leaders had to educate physicians on the value of easy access to the EHR from anywhere there is Internet access and the need for use of a common terminology to afford sharing of data and CDS tools across the healthcare organizations. Another valuable step prior to the Go-Live was to identify fifteen physician champions who represented each specialty group for the medical staff (i.e. emergency room, cardiologist, obstetrician, pediatric hospitalist, adult hospitalist, general surgeon). The vice president of medical

affairs led the physician champions through use of an engagement plan to address medical staff policies to develop and approve SSOS (order sets), to set goals for CPOE, to monitor CPOE use over verbal ordering, to develop multiple training options such as classroom, just-in-time, and to provide support in setting up favorite orders and SSOS as well as the availability of physician super users. The second milestone was met by involving all clinical disciplines early in the redesign of care delivery. Clinicians used evidence-based practices from nursing research, pharmaceutical safe practices, and clinical experts to design patient-centered process workflows that describe each step for patient care and a department and discipline specific role processes. The workflows influenced the content for the design of technology use.

When the preparation and implementation process did not exist for the clinics, we replicated parts of the preparation and big-bang implementation process that was used by the hospitals. The project management tasks for the implementation of the two clinics began with a list of 23 milestones that was condensed to 7 milestones. The initial challenge was to identify a solution for professional and facility billing in the clinic settings. Post implementation of the hospital EHR lead to a duplicated clinic registration process that required resolution. In June 2005 a month before the hospital EHR activation a solution was proposed that would include the use of Cerner Registration and Quavodx EMPI in the physician office setting. The impact would allow a workflow of one registration process. The rationale for this decision was the IDX group management practice system did not allow outbound information to a McKesson HealthQuest hospital registration system. The second milestone, the detailed redesign of workflow processes for patient and all clinic disciplines, ensured the build of components (milestone 4) necessary to meet user acceptance in milestone 6. The entire site planning of these steps to support design, implementation and changing processes would range from 970 – 1500 hours to accomplish for the initial clinic. Subsequent sites would require less effort with the use of standardized designs and workflow processes throughout the clinics. The workflow processes take more time in some areas while saving time in other steps in the clinic visits. The steps to design clinic workflows were led by nurses in collaboration with the physician champions. The nurses worked within the clinic practices for many years and one had experience using an electronic medical record within the clinic setting. The transition from one EMR without integration capabilities with other sites to an EHR with integrated data from other locations generated new challenges. A physician and clinic engagement strategy provided a variety of training forums and durations due to the variability of skills in the end users. Three physician champions were identified for the clinics to learn how to maximize use of the office EHR. The strategy included expectations for physician documentation for clinic residents and faculty. All prescriptions were entered and faxed to pharmacies. The physicians within the clinics update the problem list and the nurses update the medication list.

The evolution of Trinity Health implementation processes for the health IT technology has significantly changed from initial start-up in 2001 through 2007. Today, the clinical and information system departments jointly lead the implementation process and the ongoing clinical processes for using this health information technology. Much work effort is now dedicated to the design of evidence-based practices and clinical practice standards within the content design and the patient-centered workflows for care delivery using the EHR and other related applications. Originally, this effort was understaffed by clinicians and lacked the tools to fully develop the robust content for the practice of multiple clinical disciplines that have the ability to share and use the data, information, knowledge and application of summarizing this to promote safe and quality decisions.

Conclusions on Health IT Implementation

Overall, the HIT implementations in both the rural referral hospital and two clinics met the expectations of a very successful implementation of the Cerner PowerChart hospital and Cerner PowerChart Office EHR with CPOE. The adoption of the EHR is supplemented with software applications such as Cerner Discern Expert clinical decision support application providing nearly 200 expert rules for the health system hospitals and clinics, primarily in Michigan, Indiana and Iowa; Zynx Health Authorspace and Order Set development for CPOE at all hospitals implemented within the system; FirstNet emergency room tracking of patient progress through the system; PharmNet and Multum Drug Database and Alerts to support the verification and safety of medication ordering and prescribing; RadNet radiology; PACS radiology viewing; Cerner Care Mobile medication bar scan administration; clinic registration and scheduling was possible with ample sharing of key data elements with IDX group practice management system and McKesson HealthQuest patient management system.

Expanded use is planned for the next 2 calendar years to have almost every Trinity hospital using the EHR by the end of 2009. The success of these hospital and clinic implementations confirm the big bang process preparations and cutover to the EHR works and adoption of the EHR will be successful with systematic planning and detail work. The project team has shared many of the lessons within critical access hospitals and the other primary and specialty care clinics and at national and regional conferences over the past 3 years.

Significance

Organizational change management, clinician involvement, and project planning to redesign care delivery were significant to successfully implementing the EHR technologies and evidence-based practices. Subsequent safety, security and quality improvement mechanisms and care area teams were established to sustain the technologies and content over time. The interdisciplinary care teams are now responsible for decisions on technology and content upgrades to improve the use of the EHR. Looking beyond the implementation date was necessary to continuously advance both content and technologies after implementations. The mandate to have each person with an electronic medical record by 2014 to improve the quality, safety and efficiency of healthcare delivery system is substantiated by this project.

Implications on Health IT Implementations

The use of project management milestones and a standard process for preparation tasks and implementation tasks are recommended for hospitals and clinics to successfully implement EHR, CPOE and CDS tools. The executive leaders and especially the clinical executives, directors and managers are key persons within the change process to support the adoption of not only the healthcare information technologies but the translation of evidence-based knowledge into the redesigned workflows impacting every clinical discipline. The current health care delivery system has inherent safety and quality problems using paper systems. The current processes must be abandoned and redesign efforts undertaken to instill safety, reduce process variation and waste, prevent error-prone steps, and standardize clinical interface terminologies and data values

(units of measure) that support clinical reasoning and clinical decision making. The workflow processes have evolved over time and are central to safe and quality patient care. Thus the patient-centered clinical workflows for various types of patients provided the interdisciplinary interchange of information while the department and functional workflows became secondary. Both are important in the design and adoption of new processes but the level of interdisciplinary use of data and information are better displayed and projected to the end-user with a patient-centered flow of work which portrays the work of all disciplines when caring for the patient. It avoids duplicate and wasted efforts on the part of a care team working with patients and families/significant others. Another driving force that influences the implementation and engagement strategy was the need for physician note templates. The primary care clinics were able to implement the EHR with the support of templates for high volume diagnoses. The unavailability of physician note templates for specialized care situations limited our options to proceed with implementation in the specialty clinics. As the number of templates increase to support physician documentation, the costly dictated, transcribing and uploading processes could be reduced affording efficiencies and some cost savings.

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