Exploiting Health Information Technology to Improve Health

The MetroHealth System

Davies Award Enterprise Application

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The MetroHealth System Overview

The MetroHealth System was founded in 1836 and is the tertiary care, public/essential health system in Northeast Ohio, academically affiliated with Case Western Reserve University's School of Medicine in Cleveland Ohio.

Key operational statistics for include:

Patient Care Statistics	
Outpatient Visits	1,231,740
Emergency Department Visits	145,361
Inpatient Stays	25,943
Surgical Cases	18,648
Babies Delivered	2,979
Provider Statistics	
Physicians	507
Resident Physicians In Training	374
Nurses	1,222
Financial Statistics	
Total Operating Budget	$1.2 Billion
Total Capital Budget	$50 Million
Operating Income	$50 Million
IS Operating Budget	$35 Million
IS Capital Budget	$10 Million
% IS Operating Budget to Total	2.9%
% IS Capital Budget to Total	20%
Community Benefit	$219 Million
Payer Mix	
Commercial Insurance	28%
Medicare	25%
Medicaid	42%
Self-Pay/Other	5%

The MetroHealth System HIT Systems

Overview

The MetroHealth System (MHS) was the first public/essential health system to ever install the Epic electronic health record (EHR), going live in our ambulatory clinics starting in 1999. In 2014, the MHS became the first public/essential health system ever with the Epic EHR to achieve Stage 7 in the HIMSS electronic medical record adoption model (EMRAM) in both its inpatient hospitals and all of its ambulatory clinics. In 2017, MHS became the first public/essential health system with the Epic EHR to revalidate as a Stage 7 HIMSS EMRAM in both its inpatient hospitals and all of its ambulatory clinics.

Key HIT system implementation milestones include:

Timeline of MetroHealth-Epic Achievements

Year	Accomplishment
1999	Epic Cadence (Scheduling) Functionality Live
1999	Epic Cogito (Reporting) Functionality Live
1999	Epic Health Informatics Management (HIM) Functionality Live
1999	Epic Resolute (Professional Billing) Functionality Live
1999	Epic Tapestry (Population Management) Functionality Live
1999	Epic Clarity Extract, Transform, Load (ETL) Functionality Live
1999	EpicCare Ambulatory Functionality Live
2000	Epic EpicWeb Functionality Live
2004	ASAP (Emergency Department) Functionality Live
2005	Epic for Hospital Outpatient Departments (HODs) Live
2009	EpicCare Inpatient - ICU Live
2009	EpicCare Inpatient Functionality Live
2009	Epic Beacon (Cancer Care) Functionality Live
2009	Epic Willow (Pharmacy) Inpatient Functionality Live
2009	EpicCare Inpatient Computerized Physician Order Entry (CPOE) Functionality Live
2009	Epic Supported Clinical Informatics Fellowship
2010	Epic Care Everywhere (Health Information Exchange) Functionality Live
2011	Epic Customer Relationship Manager (CRM)/Call Management Functionality Live
2011	Epic Nurse Triage Functionality Live

2011	Epic MyChart Functionality Live
2011	Dr. Greco Wins Inaugural PACademy
2011	Epic Attention Deficit Hyperactivity Disorder Medication Daisy Chain Functionality Live
2012	MetroHealth signs Epic Enterprise contract
2012	Epic Health Maintenance for Pediatric Immunizations Live
2013	MetroHealth Extends Epic to the Cleveland Public School District
2013	Epic Radar Executive Dashboards Live
2013	Epic Welcome Patient Kiosk Functionality Live
2013	Epic EpicCare Link Functionality Live
2013	Epic Prelude (Registration) Functionality Live
2013	HIMSS Stage 6 for Inpatient and Ambulatory
2014	MetroHealth Extends Epic to the Jail
2014	MetroHealth Creates the Enrollment Outreach Mobile Unit
2014	Epic OpTime OR Management System Functionality Live
2014	Epic Anesthesia Functionality Live
2014	Epic Grand Central (Patient Flow) Functionality Live
2014	Epic Resolute (Hospital Billing) Functionality Live
2014	Epic Beaker (Pathology) Functionality Live
2014	Epic Pediatric Wellness Registry Functionality Live
2014	Most Wired Hospital Award
2014	HIMSS Stage 7 for Inpatient and Ambulatory Initial Certification
2015	MetroHealth Helps Start Epic's Physician Advisory Council Advisory Board
2015	Epic Kaleidoscope (Ophthalmology) Functionality Live
2015	Epic Caboodle (Enterprise Data Warehouse (EDW)) Functionality Live
2015	Epic Haiku/Canto (SmartPhone/Tablet) Functionality Live
2015	Most Wired Hospital Award
2016	Epic Lucy (patient-controlled person health record) Functionality Live
2016	Most Wired Hospital Award
2017	Spry Personal Concierge Clinic Opens

2017	Dr. Bar Shain Wins PACademy
2017	Epic Predictive Analytics Functionality Live
2017	Epic Stork (Obstetrics) Functionality Live
2017	Epic Healthy Planet (Population Health) Functionality Live
2017	Most Wired Hospital Award
2017	HIMSS Stage 7 for Inpatient and Ambulatory Recertification
2018	First Organization to Submit to Epic's Cosmos Database
2018	Epic Clinical Case Management Functionality Live
2018	Epic Health Effectiveness Data and Information Set (HEDIS) Measures Functionality Live
2018	Epic Infection Control Functionality Live
2018	Epic Rover (Nurse Handheld) Functionality Live
2018	Cum Laude Honor Roll
2018	KLAS Arch Collaborative (Electronic Health Record End User Experience - Top 10 Epic Customer)
2018	Most Wired Hospital Award
2019	MetroHealth Extends Mobile Mammography
2019	Creation of Physician Advisory Council (PAC) Mentorship Program
2019	Most Wired Hospital Award
2019	Most Wired Ambulatory Award
2019	Summa Cum Laude Honor Roll

Larger Electronic Health Record Community Contributions

Notable External Recognition for MHS HIT-enabled efforts:

- *Underdiagnosis of Hypertension in Children and Adolescents* (2007 – American Health Association top 10 cardiac research advances)
- *Electronic Medical Record Assisted Design of a Cluster-Randomized Trial to Improve Diabetes Care (Cluster randomized trial for informatics* (2008 – Cluster randomized for informatics research recognized by the American Medical Informatics Association (AMIA) as one of the top 10 informatics advances)
- Electronic disease reporting for public health (2009 – 2nd site to implement Electronic Support for Public Health (ESP) software)
- *Electronic Health Records and Quality of Diabetes Care* (2011 – one of the AMIA top 10 informatics advances)
- *Advanced Clinical Decision Support for Vaccine Adverse Event Detection and Reporting* (2011 – EHR immunization adverse event reporting to the Centers for Disease Control and Prevention (CDC); first known site in the US to automate detection and reporting of vaccine adverse events to the CDC)
- Use of the EHR to combat *Acinetobacter* (2011 – Association of Medical Directors of Information Services (AMDIS) award)
- Increase of Up-To-Date Pediatric Immunizations (2012 – designated by the Epic Corporation as a "Clinical Program" and recognized by The Joint Commission as a "best practice" immunization tracking and ordering system)
- *Stepping Stones of Pediatric Hypertension: Advanced Decision Support Helps Identify High Blood Pressures* (2013 – American Academy of Pediatrics National Conference and Exhibition Council of Clinical Information Technology "best poster" award)

MHS staff presented over 75 presentations at Epic User and Expert Group vendor EHR conferences, including several "classics" lectures (voted on by other Epic customers). Dr. Peter Greco was also one of the first people to win the Epic Corporation's PACademy award (nominated and selected by fellow Epic customer physicians as making extraordinary contributions to the Epic community).

A bibliography of the more than 125 MHS presented or published EHR related scientific abstracts and manuscripts is included in Appendix A. This work exemplifies:

1. How MHS continuality strives to evaluate, generalize and disseminate EHR (and HIT) related activities for others to benefit from
2. How MHS uses EHRs to perform novel non-EHR specific research

Acknowledgments/Dedication

This Davies award enterprise application would not have been possible without the efforts of thousands of people throughout the MHS and our partners over the last two decades. These individuals (past and present) share a vision for health information technology. They have worked and continue to work together to enable the MHS to use health information technology to help achieve the MHS's vision to "be the most admired public health system in the nation, renowned for our innovation, outcomes, service and financial strength." We dedicate this Davies application to all the individuals who have helped make the accomplishments documented in the application possible and to our patients and community whose health we are continuously working to improve.

Core Case Study: Clinical Value

Executive Summary

The MetroHealth System (MHS), a safety-net/essential healthcare system in Northeast Ohio affiliated with Case Western Reserve University's School of Medicine, started to implement the Epic electronic health record (EHR) throughout MHS ambulatory clinics in 1999. By 2009, the MHS had fully deployed Epic enterprise-wide: throughout all ambulatory clinics, inpatient areas, and the emergency department. Over the last five years the MHS has focused on enhancing the use of the existing EHR foundation to do things not possible without a fully deployed, enterprise EHR and to meet ongoing MHS needs.

Local Problems

The MHS views the EHR as a critical component of administrative, clinical, operational and quality activities. As such, numerous areas of the healthcare system are continually asking if/how the EHR can help issues/opportunities their areas are interested in. Additionally, information services and informatics staff are always looking for opportunities to leverage existing and new EHR functionality in ways to improve the MHS.

The health information technology (HIT) value examples described in this section represent a broad sampling for the local problems the EHR has been used to address within the MHS.
The HIT value examples include:

- Health information exchange
- Heparin (high risk medication)
- Code status reconciliation
- Vaccine adverse event reporting
- Outpatient depression screening
- Automated patient clinical messaging
- Internal referral completion
- Common high risk/high cost hospital acquired infections
- Core measures
- Blood pressure diagnosis research and improvement

Health IT Value Example: Health Information Exchange

Brief Overview

The Health Information Exchange value case primarily demonstrates electronic health information exchange/data value in terms of the HIMSS STEPS Model, but the MHS experience also shows value in patient satisfaction and operational and efficiencies savings. For over a decade, the MHS has recognized the potential to significantly improve healthcare value (quality of care / cost of care) through electronic health information exchange (HIE). To achieve the enhanced value with HIE, HIE must also be efficient and integrated into the clinical work flow to the greatest degree possible and ideally also improve patient satisfaction. An overview of the MHS's HIE strategy appears in Figure 1.

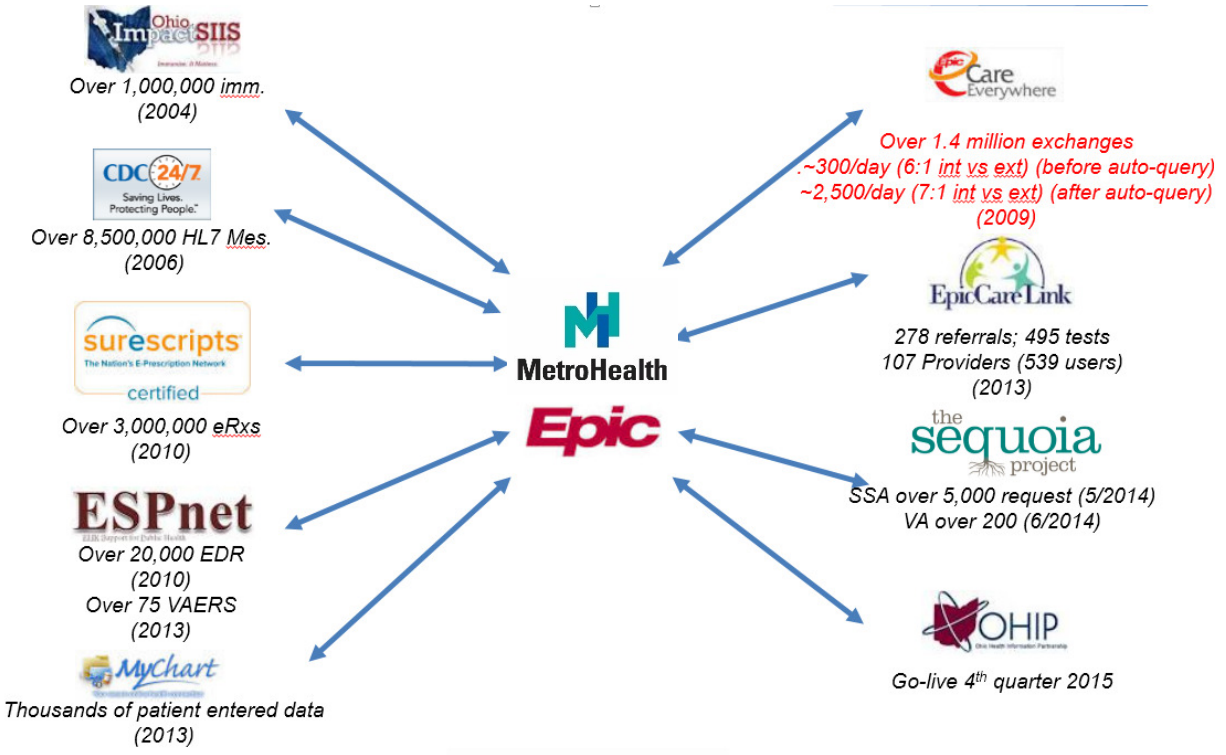


Figure 1 – MHS electronic health information exchange overview

Care Everywhere Initial Efforts and Evidence of Value

Within our overall HIE efforts, over the last five years MHS has specifically focused on implementing and evaluating real-time, two-way clinical HIE through Epic's Care Everywhere platform. Although the MHS was involved in a number of HIE efforts prior to Care Everywhere, none involved real-time, two-way clinical information exchange. The MHS first implemented Care Everywhere in the fall of 2010, starting in our Emergency Department as a pilot and then expanding throughout our healthcare system in the beginning of 2011. At the time, we deployed Care Everywhere in conjunction with the Cleveland Clinic Foundation (another Epic customer in Northeast Ohio). Initially, written consent was required to initiate the search process to locate information in other Epic systems.

Through the first 14 months of Care Everywhere's implementation, the MHS carefully monitored Care Everywhere's use and assessed its value through a combination of objective data and user surveys. Figure 2 shows the use of Care Everywhere in its first 14 months by site of care. Highlights of these findings show that HIE was used on ~6% of patients. Almost 80% of providers who used Care Everywhere indicated that it caused them not to order a test (lab or imaging) that they were otherwise planning to order and approximately 17% of providers who used Care Everywhere stated that is caused them not to admit a patient they were otherwise planning to admit (Figure 3). Table 1 shows patient characteristics associated with an increased odds ratio of having electronic health information occur. The complete findings of our initial Care Everywhere analysis were published in 2013 in a special health information technology issue of the American Journal of Managed Care – *Use and Perceived Value of Health Information Exchange – One Public Healthcare System's Experience*.

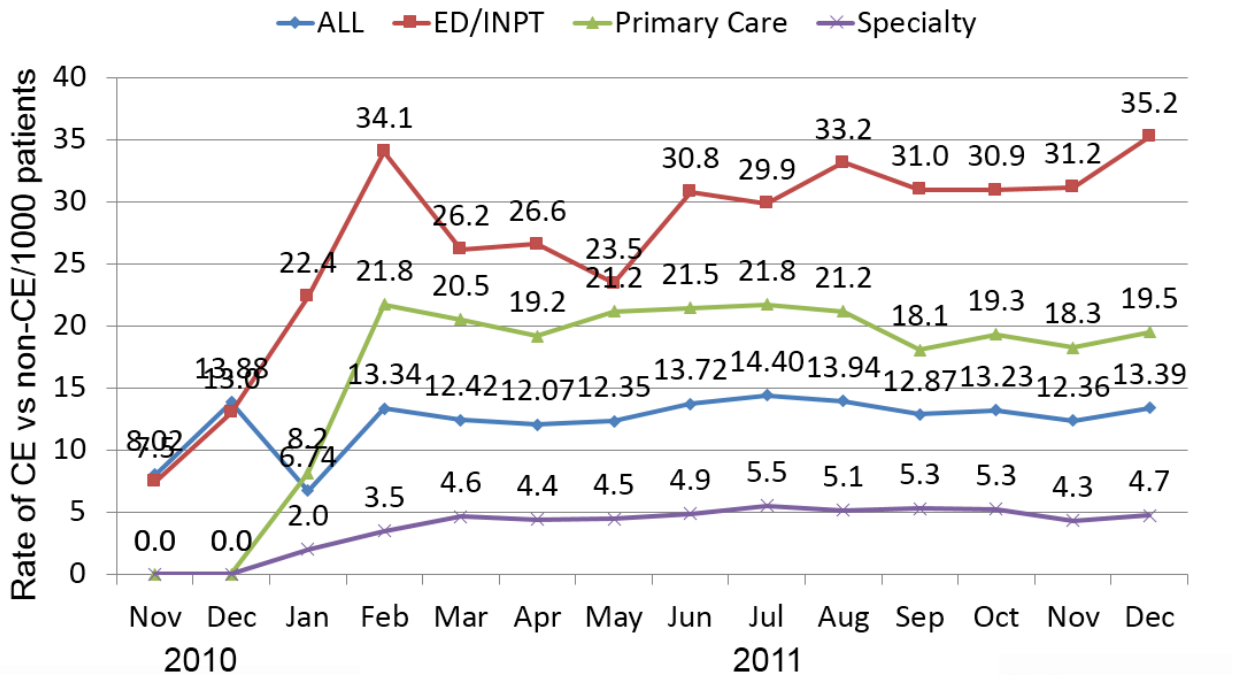


Figure 2 – MHS rate of Care Everywhere (CE) patients versus non-CE patients/1,000 patients by care setting

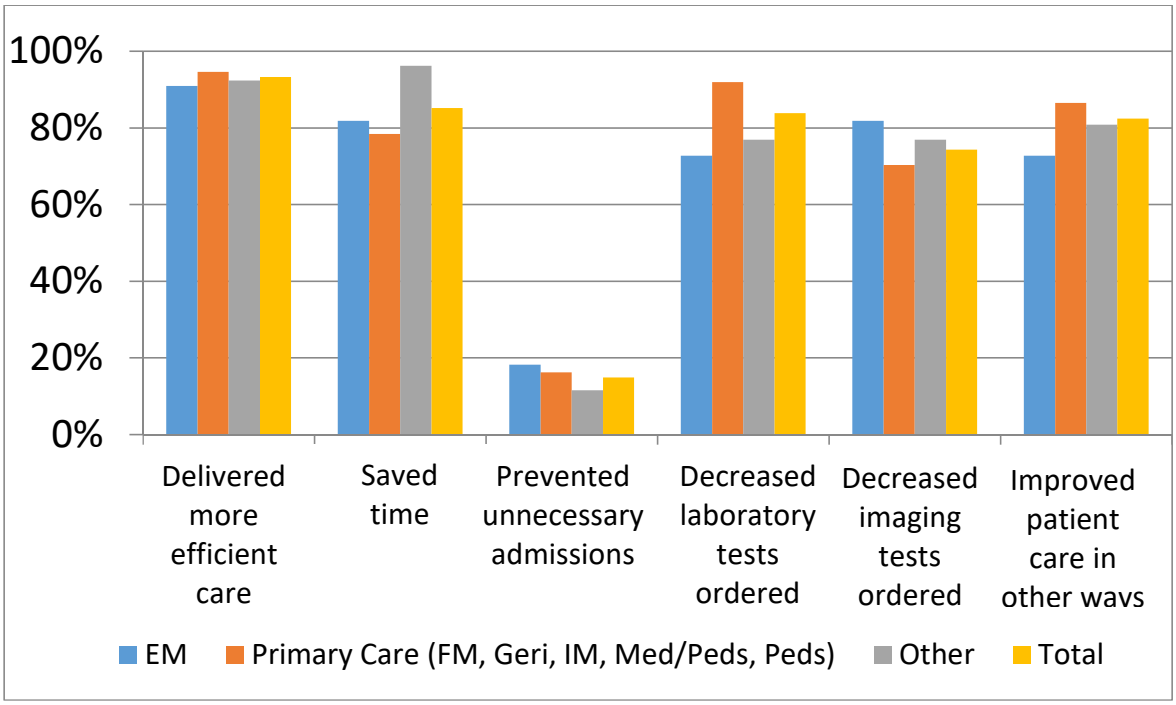


Figure 3 – Self-reported impact of Care Everywhere on providers, by type of provider, who had used Care Everywhere at least one-month post-go-live

Characteristic	Odds Ratio (95% CI)
Mean Age (years)	**1.009 (1.007-1.011)**
Sex (%)	
Male	Ref.
Female	**1.09 (1.04 – 1.15)**
Race/Ethnicity (%)	
White	Ref.
African American	**1.12 (1.07 – 1.18)**
Hispanic	0.98 (0.89 – 1.09)
Other / Unknown	**0.55 (0.49 – 0.61)**
Insurance (%)	
Commercial	**0.78 (0.73 – 0.83)**
Medicare	**1.22 (1.14 – 1.30)**
Medicaid	**1.12 (1.04 – 1.20)**
Uninsured	Ref.
Mean # of Comorbidities	**1.29 (1.27 – 1.31)**

Table 1 –Objective patient characteristics comparing those patients who had at least one Care Everywhere encounter and those having no Care Everywhere encounters. Odds ratios of statistically significant characteristics are BOLDED – increased age, female gender, African American and Others/Unknown race/ethnicity, commercial, Medicare and Medicaid insurance and increasing numbers of co-morbidities

Care Everywhere Continued Efforts and Evidence of Value

Since our initial implementation and evaluation of Care Everywhere, the MHS has continued to enhance its HIE capabilities and track its progress knowing that the higher the volume of HIE that occurs and the more information the MHS can exchange in each HIE, the better care the MHS can provide to its patients.

Highlights of recent efforts include:

1. February 2014 – became one of the first Epic customers to begin data exchange with Social Security Administration (SSA) through the Sequoia Project (formerly known as the Healtheway). For every data exchange that the SSA pulls from the MHS, the MHS receives ~$10 net payment.
2. June 2014 – became one of the first Epic customers to begin data exchange with the Veterans Administration through the Sequoia Project (formerly known as the Healtheway).
3. Summer 2014 – led regional effort to implement nightly and ED/inpatient ADT "auto-querying" for all Care Everywhere sites within a 150 mile radius of healthcare system and patient zip codes.
4. November 2014 – CMIO became member of the Epic Corporation's Care Everywhere Governing Council.
5. May 2015 – became one of the first Epic customers to implement non-ED walk-in/same-day ADT "auto-querying" for all Care Everywhere sites within a 150 mile radius of healthcare system and patient zip code.
6. June 2015 – became one of the first Epic customers to implement fully integrated pediatric growth chart integration of external data (Figure 4).

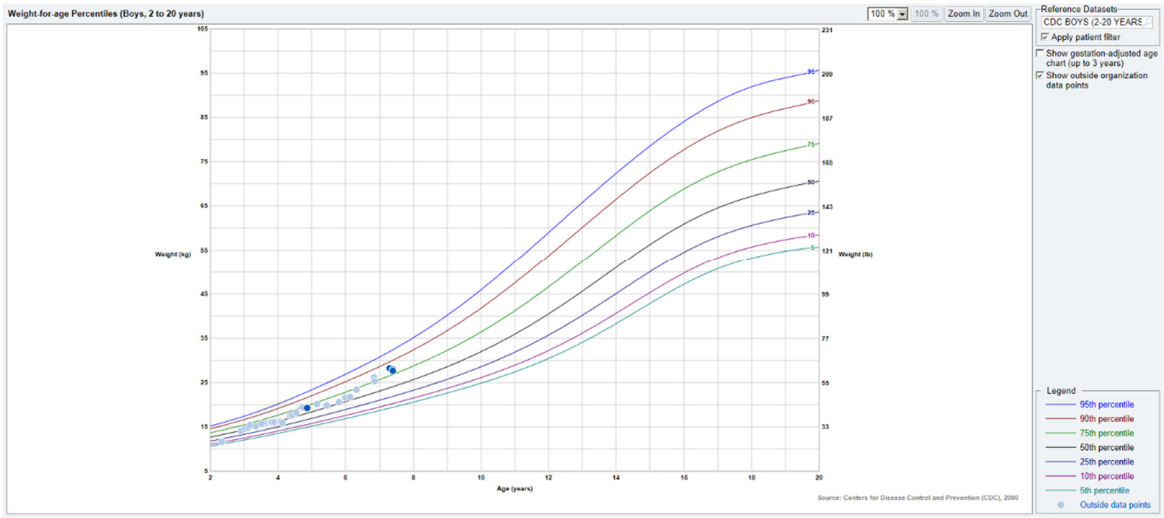


Figure 4 – Electronic health record screen shot of patient with fully integrated external growth chart data (light blue circles) combined with native electronic health record data (dark blue circles)

Figure 5 summarizes our overall Care Everywhere volumes over the last year. Figure 6 shows our continued monitoring of Care Everywhere metrics at the end of the first half of 2015.

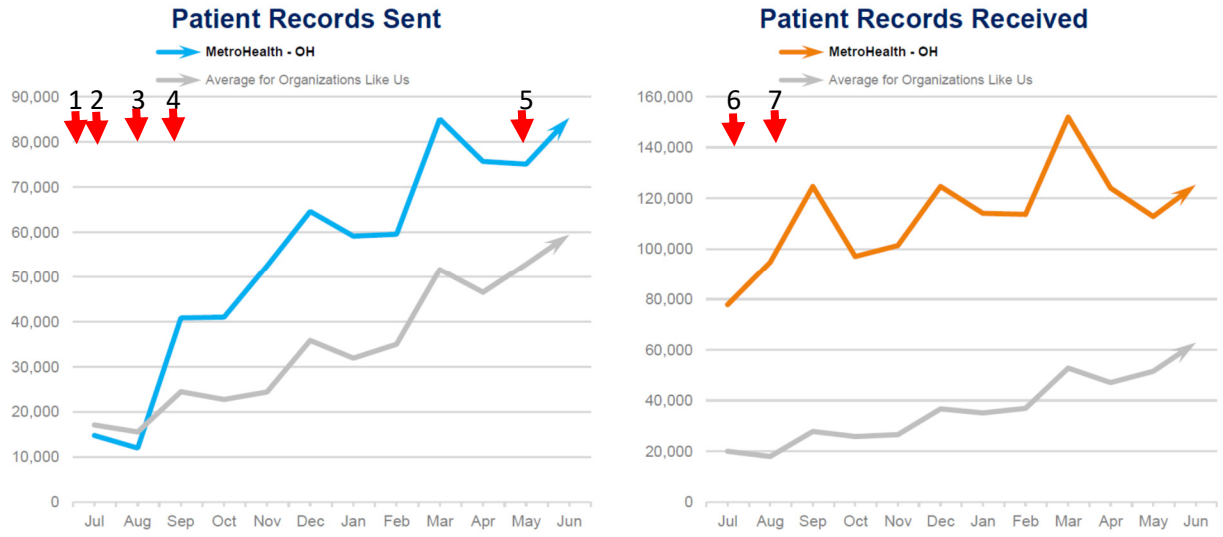


Figure 5 – Patient Records Sent and Received from MetroHealth through Care Everywhere from April 2014-March 2015, compared to Epic Community Average Peer Institutions. 1 – HIE Go-Live with Social Security Administration, 2 – HIE Go-Live with Veterans Administration, 3 – Encouraged Regional CMIOs at other institutions to drop separate written consent requirements for HIE, 4 – Encouraged Regional CMIOs at other institutions to adopt auto-querying overnight batch and ED/inpatient admission querying process, 5 – Began auto-querying for same-day/walk-in appointments, 6 – Dropped separate written consent requirements for HIE, 7 – Began auto-querying overnight batch and ED/inpatient admission

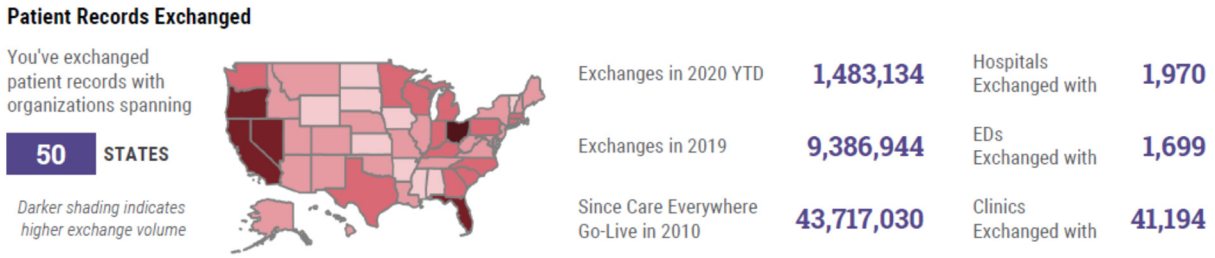


Figure 6 – Ongoing Care Everywhere metrics shown at the end of first half of 2020.

Implementation and Value Summary

Overall, our decade long strategic focus on HIE, focusing specifically on Care Everywhere over the past five years, has led to many fold increases in the volume of electronic documents exchanged. This increase in volume of electronic documents exchanged has led to increased provider efficiency, enhanced patient experience and decreased healthcare costs because of fewer tests being ordered and fewer patients being admitted. Quantifying the decrease in healthcare costs because of fewer tests and fewer admissions is complicated, and in the current

healthcare system, these decreased costs manifest themselves as decreased MHS charges and therefore decreased revenue for MHS because the real cost savings is to the payer. For uninsured patients within the MHS, MHS acts as their payer and so cost savings for this group results in more direct savings to MHS. Estimates of the ROI of HIE for the MHS (based on SSA payments and decreased testing and admissions among the uninsured patients calculated as 2% cost elimination among the 6% of our uncompensated care (uninsured) patients that had HIE since HIE was available) appear in Table 5 of the Core Case Study: Financial Value.

Health IT Value Example: Heparin (high risk medication)

Brief Overview

The Heparin value case exemplifies a treatment/clinical case from the HIMSS STEPS model. After a sentinel event at the MHS involving heparin led to a patient safety network (PSN) report, a root cause analysis identified several EHR factors as potentially causing patient safety issues related to heparin, including:

- Multiple (eight) versions of heparin order sets and protocols
- No discrete location or standardized method to document bolus doses
- Multiple versions of protocols on different internal websites (pharmacy, nursing, and Epic) on our corporate network
- Some hyperlinks in Epic directing staff to outdated protocols
- No method to document second nurse verification for high risk medication administration

An interdisciplinary team was established to address all identified root cause analysis issues, as follows:

- Single heparin order set and protocol standardized throughout all care settings (Figure 1)
- All protocol links consolidated to point to single, updated protocol (Figure 1)
- Standardized method to document all heparin bolus doses (Figure 2)
- Development and implementation of second nurse verification work flow for heparin and other high risk medication administrations (Figure 3)

Figure 1 – Electronic health record screen shot of single standardized heparin order set with consolidated protocol link

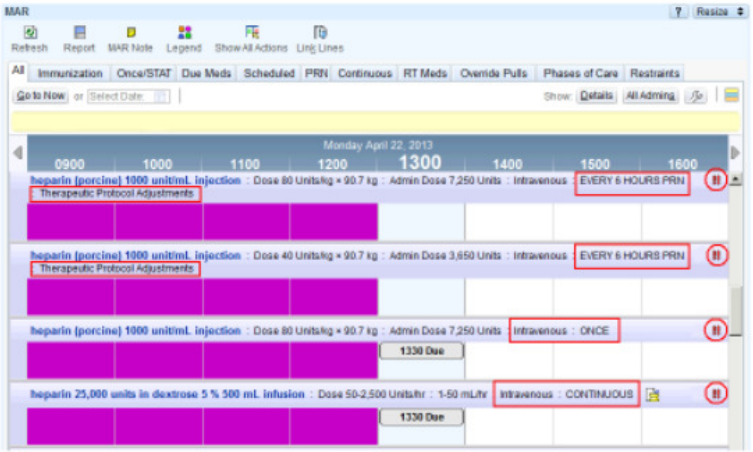


Figure 2 – Electronic health record screen shot of standardized method to document all heparin bolus doses (continuous, bolus and PRN)

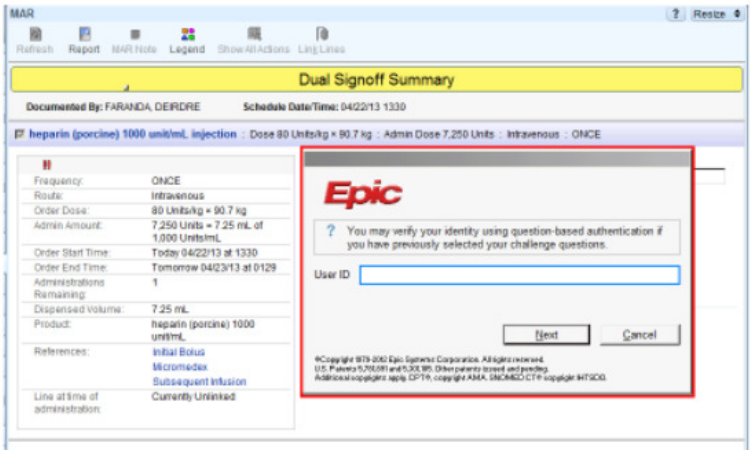


Figure 3 – Electronic health record screen shot of dual RN sign-off developed and implemented for heparin and other high-risk medications

Evidence of Value

In 2011, the year the heparin sentinel event occurred, MHS had 3 PSN Heparin related errors with patient harm. Since identifying and addressing all root cause analysis issues, no PRNs related to patient harm from heparin have occurred in MHS (Figure 4).

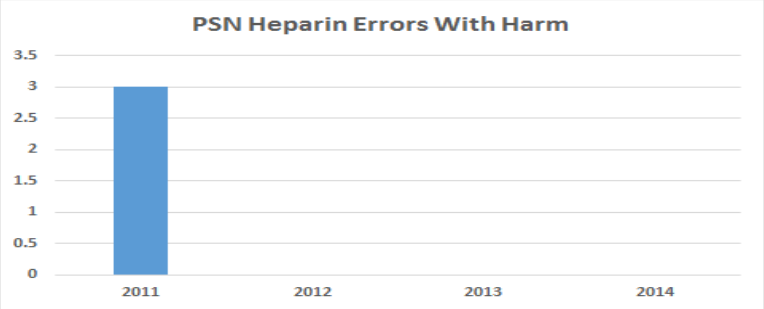


Figure 4 – Patients Safety Network (PSN) reports of Heparin Errors causing patient harm (2011-2014)

Health IT Value Example: Code Status Reconciliation

Brief Overview

The Code Status Reconciliation value case primarily demonstrates prevention from the HIMSS STEPS model, but also demonstrated the long-term potential for increased patient satisfaction and improved clinical outcomes. After a critical event in our health system in which a patient's code status was not honored, MHS evaluated ways to decease the chance that a patient's code status would not be honored in the future. MHS realized that code status reconciliation, especially at discharge from the inpatient setting, when the inpatient code status does not match the prior to admission code status, was a significant opportunity for reconciliation of non-medications (in the same way that hospital discharge is a very important opportunity for medication reconciliation). We implemented standard clinical decision support functionality within our Epic electronic health record to prompt the discharging physician if the inpatient code status did not match the prior to admission code status and force the physician to reconcile the code status (Figure 1). Implementation of code status reconciliation at discharge has significantly increased non-full-code code status within the patients' record at/after discharge (10% for do not resuscitate comfort care arrest do not intubate and 50% for do not resuscitate comfort care arrest intubate).

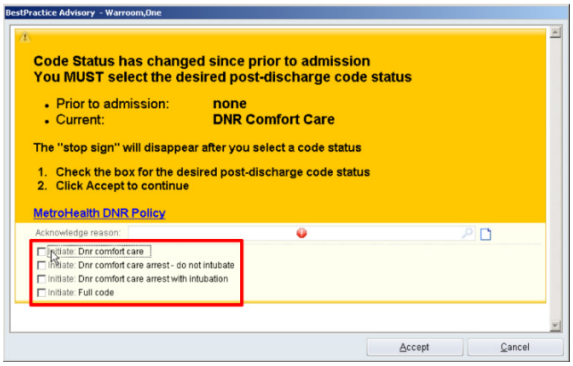


Figure 1 – Code status reconciliation clinical decision support at discharge

Evidence of Value

The overwhelming majority of patients have the same code status prior to hospitalization as they do during their hospitalization, which is most commonly a full-code code status. The goal of code status reconciliation is to ensure that code status changes during an inpatient admission (most commonly changing from a full-code code status to a non-full-code code status) are honored. Figure 2 shows the change in non-full-code code status among outpatients before and after code status reconciliation clinical decision support (red arrow) was implemented (immediate outcome measure of code status reconciliation). Figure 3 shows the change in non-full-code code status before and after code status reconciliation clinical decision support was implemented (red arrow) in new admissions (long-term outcome because the reconciled code status at discharge now continues to be apparent at re-admission/re-presentation).

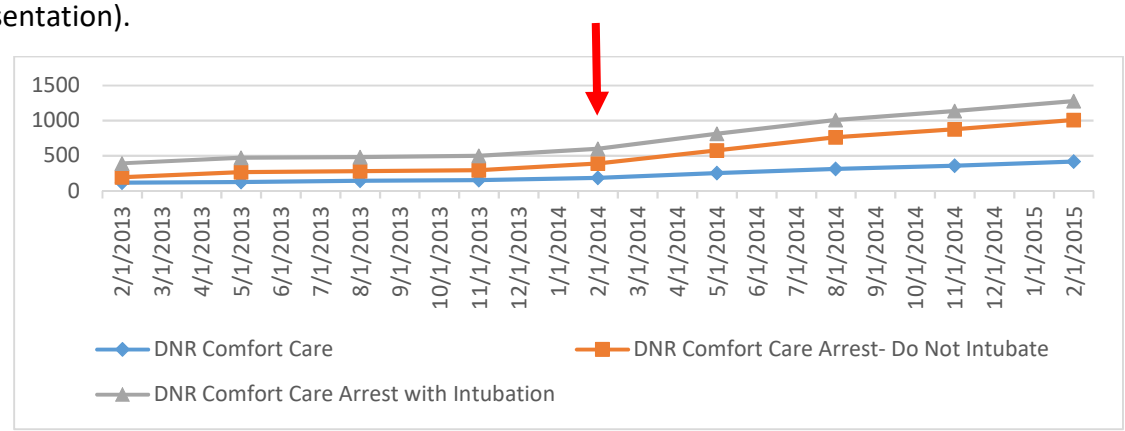


Figure 2 – New outpatient non-full-code code statuses per month before and after code status reconciliation clinical decision support was implemented in 2/2014 (red arrow)

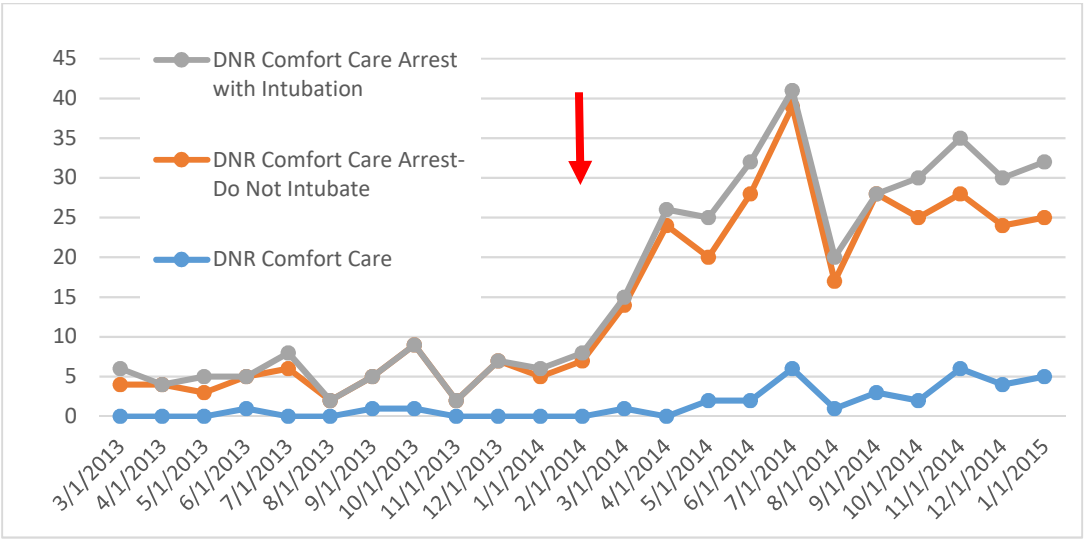


Figure 3 – Non-full-code code status at readmission/re-presentation to inpatient/ED settings per month before and after code status reconciliation clinical decision support was implemented in 2/2014 (red arrow)

Health IT Value Example: Outpatient Depression Screening

Brief Overview

The Depression Screening value case exemplifies treatment/clinical care improvement from the HIMSS STEPS model for patients with depression using the electronic health record (EHR). MHS did not have a quantitative, reproducible and systematic way to screen for depression. Therefore, in the spring/summer of 2013, the MHS implemented a suite of tools and processes in our EHR to routinely screen annually all adult patients presenting to primary care appointments using the validated PHQ-9 depression screening tool. EHR tools and process included:

1. Automatic printing of the PHQ-9 tool on pre-visit summaries at check-in (Figure 1)
2. Development of specialized EHR section for entry of PHQ-9 patient reported data (Figure 2)
3. Clinical decision support for provider for identification of patients with "positive" PHQ-9 screening scores (Figure 3)
4. Smart sets for providers to drive evidence based care for patients with "positive" PHQ-9 screening scores (Figure 4)
5. Automatic After Visit Summary educational materials for those patients with "positive" PHQ-9 screening scores

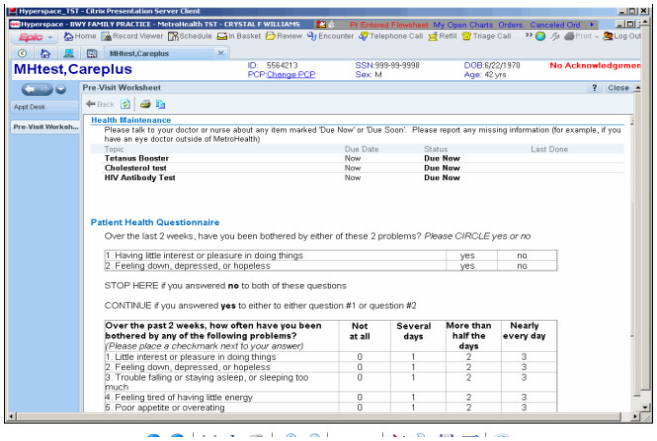


Figure 1 – Example of PHQ-9 pre-visit questionnaire automatically printed for appropriate patient at check-in

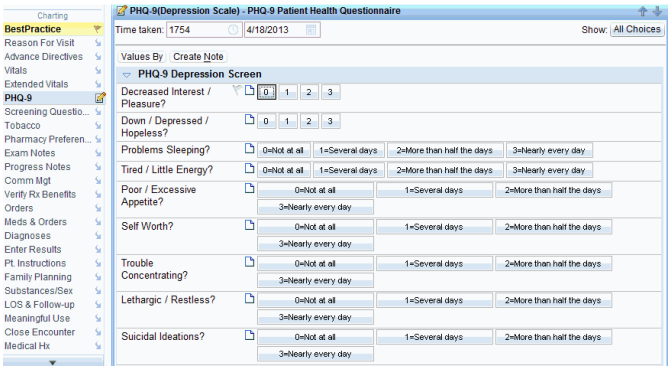


Figure 2 – Electronic health record screen shot of specialized PHQ-9 patient reported data collection tool

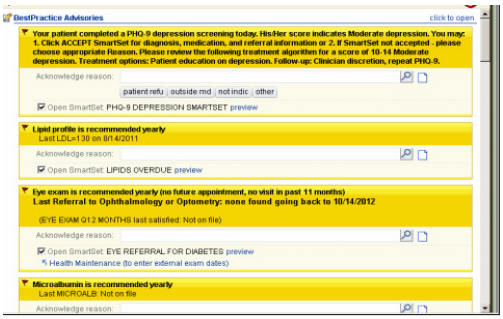


Figure 3 – Electronic health record screen shot showing clinical decision to provider for patients with "positive" PHQ-9 scores

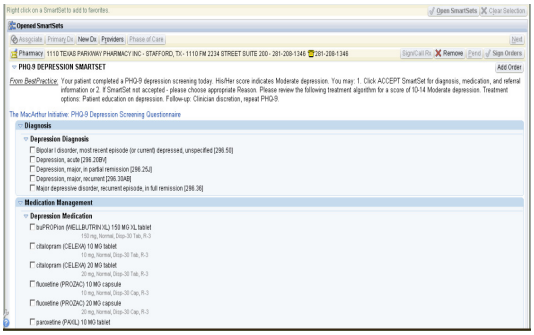


Figure 4 – Electronic health record screen shot with Smart Sets associated with clinical decision to drive evidence based care for patients with "positive" PHQ-9 scores

Evidence of Value

We analyzed the overall impact from September 2013 through December 2014, comparing depression screening and treatment after the implementation of advanced clinical decision support for patient subjective PHQ-9 data collection for depression screening. During this period screening rates increased by 15 fold and depression detection increased by 230% (6.45% to 14.87%). Figure 5 shows the number of PHQ-9 SmartForms completed over time.

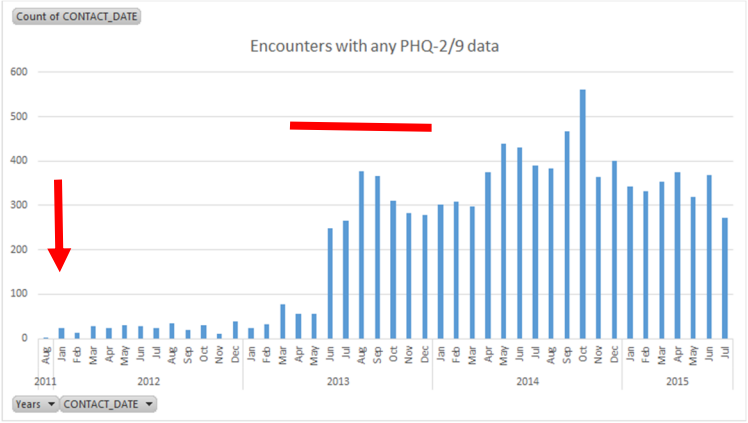


Figure 5 – PHQ2/9 SmartForm use throughout the MHS over time. The PHQ2/9 was first built into our Epic system in the beginning of 2012 (red arrow). Use was very limited until a system of PHQ2/9 use and staff education was provided, which occurred in the spring/summer of 2013 (red horizontal line).

Health IT Value Example: Vaccine Adverse Event Reporting

Brief Overview

The Vaccine Adverse Event Reporting combines treatment/clinical care improvement, electronic secure data exchange and population management aspects of the HIMSS STEPS model. All providers are responsible for evaluation of and reporting to the Centers for Disease Control and Prevention (CDC) possible, probable and confirmed adverse vaccine events. However, many studies document that 1) providers miss vaccine adverse events and 2) even if a provider identifies a possible/probable/confirmed vaccine adverse event they are not aware of the requirement of report to the CDC and/or are not aware of how to report to the CDC. We were the first site in the US to develop a system using the open-source Electronic Support for Public health (ESP) platform (http://www.esphealth.org) connected with our Epic electronic health record (EHR) to identify and report vaccine adverse events. Daily ETL (extract, transform and load) feeds occur between ESP and our EHR including demographic, diagnoses, immunization and laboratory information. Intelligent algorithms in ESP identified possible and probable vaccine adverse reactions. Probable vaccine adverse reactions were sent directly to the CDC vaccine adverse reporting system, along with a message back into the provider's in basket in the EHR notifying them that the vaccine adverse reaction had been detected and sent. Possible vaccine adverse reactions were sent into the provider's in basket (Figure 1) in the EHR for one-click confirmation/verification prior to being sent to the CDC.

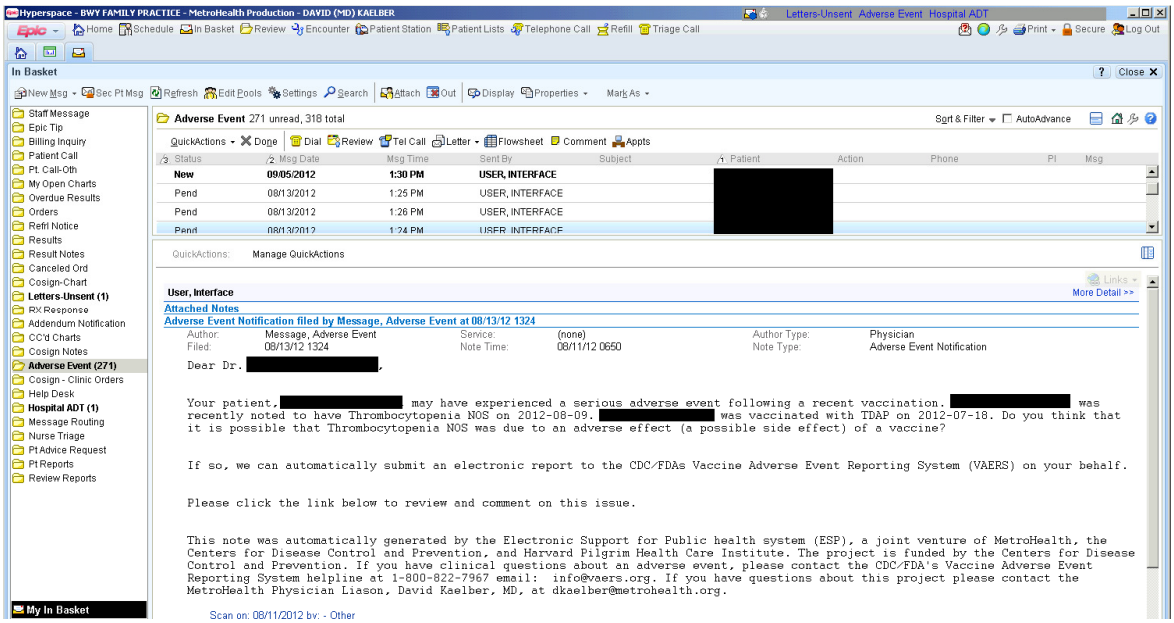


Figure 1 – Electronic health record screen shot showing ESP vaccine adverse event verification message in the provider's in basket

Evidence of Value

Over the first year after implementation of the vaccine adverse event reporting system (VAERS) functionality, a 30 fold increase in vaccine adverse event reporting was found (Table 1). Details of this system, its implementation and results can be found in our publication in Clinical

Infectious Disease – *Advanced Clinical Decision Support for Vaccine Adverse Event Detection and Reporting.*

	VAERS Reports	Time	Reports/ Month	Vaccinations	Reports/100,00 Vaccinations
Retrospective Control	3	2 years	0.11	274,080	1.09
Post-Implementation	32	1 year	4	91,622	34.9

Table 1 – Comparison of vaccine adverse event reports during the retrospective control period compared to the post-implementation data period

Health IT Value Example: Automated Patient Clinical Messaging

Brief Overview

The Automated Patient Messaging value case primarily demonstrates a patient engagement and population management case from the HIMSS STEPS model, but also exemplified treatment/clinical and patient satisfaction. It has also had a positive financial impact. In line with overall MHS efforts to improve population health, MHS has increased the utilization of automated messaging reminders to patients to complete recommended clinical activities such as health maintenance measures (e.g. vaccinations) and laboratory and imaging testing. These measures built upon initial efforts that utilized automated messaging for appointment reminders. To date we have developed automated patient clinical messaging programs in the following areas:

- Adolescent immunizations (automated texting, automated calls and personal health record reminders [2012])
- Adult immunizations (automated texting, automated calls and personal health record reminders [2013], also special data entry linked personal health record reminders for annual influenza vaccines [2014])
- Laboratory tests (automated texting and automated calls [2012])
- Radiology tests (automated texting and automated calls for advanced imaging [2014], also special personal health record messaging with self-scheduling for breast imaging [2015])

Evidence of Value

Adolescent Immunization Messages

After implementing a full suite of best practice advisories and clinical decision support tools in Epic for all pediatric immunizations (which subsequently became an Epic Corporation Clinical Program in 2013), we leveraged this electronic health record "registry" of adolescents overdue for at least one immunization (DTaP, MCV or HPV) to message (automated texts, automated phone call or automated post-card) these patients/their parent using a third-party vendor (TeleVox). MHS studied the impact of messaging on immunization completion rates within six months of messaging from April 2012 to March 2013. The "number needed to message" was approximately four (i.e. send messages to four patients/parents in order to have one patient/parent, receive the message, schedule an appointment, come to the appointment and receive their missing immunization). The development of the infrastructure for this work was

funded by a $150,000 grant from the Society of Adolescent Health. Once the infrastructure was built, we spent ~$5,000 in messaging expenses to bring in ~$200,000 in increased net revenue (ongoing ~$17,000/month net ROI in 2015 dollars). Because of the success of this project during the grant period, which ended in 2013, we have continued this patient/parent messaging and plan to continue for the indefinite future. The details of this project were recently published in the Journal of Adolescent Health – *Direct Messaging the Parents/Guardians to Improve Adolescent Immunizations*. In addition to the significant increase in immunizations (tens of thousands of immunization have been given as a result of immunization messages to date) and revenue (hundreds of thousands of dollars have been generated because of immunization messages to date) we have also had numerous anecdotal stories of how patients/parents "love that we are reminding them/communicating with them/thinking about them" outside of a face-to-face visit.

Adult Immunization Messages

Adult immunization patient clinical messages were implemented in the second half of 2013 for HPV, Zoster, Pneumococcal vaccines, based on the MHS's experience and infrastructure built for adolescent patient clinical messages. Table 1 shows the impact of automatic patient clinical messages for adult immunizations. Adult immunization patient clinical messages are estimated to be contributing to an additional 1,140 adult immunizations per month throughout MHS, contributing to an estimated ~$10,000/month in additional net revenue.

In the fall of 2014, we also sent 14,744 personal health record messages for flu shot reminders. Although using the personal health record to send patient clinical messages is not unique, we were one of the first Epic customers to enable patients to report external flu vaccine (i.e. flu vaccines obtained outside of our healthcare system) through MHS flu shot reminder clinical messages (Figure 1). 684 patients (4.63%) report external flu vaccines. MHS efforts using personal health records to have patients enter external immunization data has been written up by our EHR vendor as a model clinical program as part of their *Success at Seven* program (https://galaxy.epic.com/Search/GetFile?url=1%2168%21100%213076248). MHS subsequently expanded personal health record immunization reminder messages with patient data entry for all adult immunizations. Figure 2 shows the results of patient entered data among the 12% of patients who responded with patient data entry.

Intervention	Period	Total	Zoster	TDaP	Pneumococcal	HPV
Baseline (average/month)	Jan-Apr	2078	110	1274	510	184
HMRs*	June	3001	228	1910	603	179
BPAs/Sset**	August	3218	380	1985	644	209
% Impr. over baseline***		54%	245%	56%	26%	14%
Estimated ongoing additional immunization per month		1140	270	711	134	25

** - Health Maintenance Reminders (HMRs) implemented 5/10/2013*
*** - Best Practice Advisories (BPAs)/SmartSets (Ssets) implemented 7/12/2013*
**** - As measured in 8/2013*

Table 1 – Impact of adult immunization automatic patient clinical messages

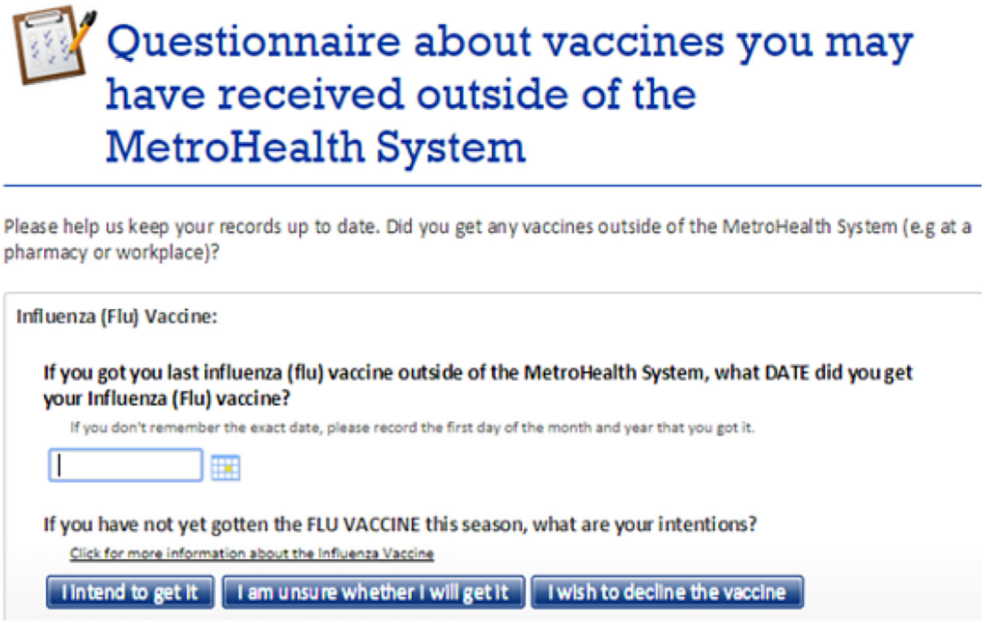


Figure 1 – Data entry form in the PHR for patients to enter external flu vaccines

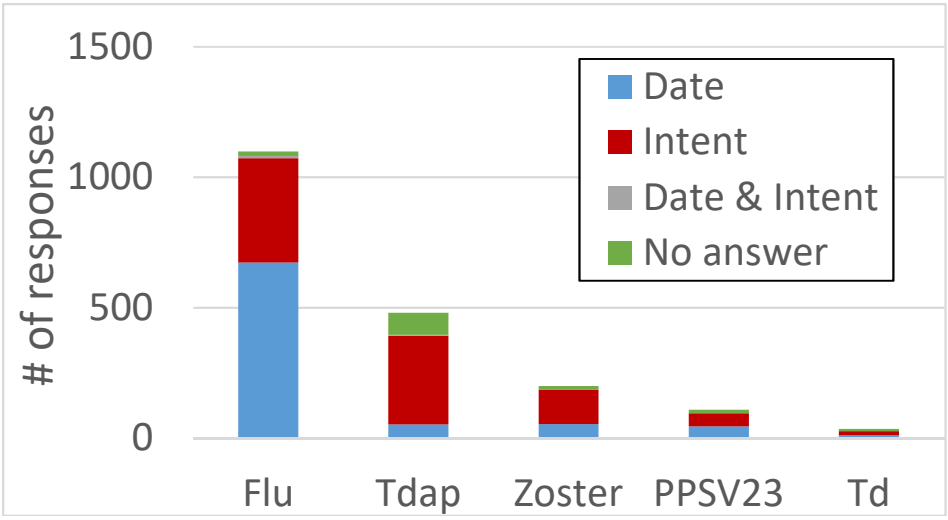


Figure 2 – Results of patient entered immunization data among the 12% of patients who entered data in response to a personal health record immunization reminder for the five common adult immunizations

Laboratory Patient Clinical Messages

For laboratory patient clinical messaging, we messaged (automated phone calls starting in 2012 and automated text messaging starting in 2014) all patients one time who have had a laboratory test that had been ordered, but not resulted within three weeks. We then measured the completion of the test during the fourth week at baseline and with messages. We periodically pause messaging to re-evaluate the effectiveness of this program. Table 2 shows the laboratory messaging evaluation over time. We have estimated that in addition to the better care provided as a result of laboratory test reminders, increases in treatment/clinical

care provided by laboratory test reminder messages results in ~$6,500 per week ($26,000 per month) in additional laboratory revenue.

Evaluation Date (sample size)	Baseline Completion Rate	Automated Phone Calls Completion Rate	Automated Text Messages Completion Rate
6/2012 (200)	23%	36%	n/a
9/2012 (643)	n/a	43%	n/a
2013 (200)	8%	21%	n/a
11/2014 (100)	n/a	50%	30%
1/2015 (100)	n/a	34%	24%
2/2015 (100)	n/a	44%	38%
Average	16%	38%	31%

Table 2 – Impact of automated phone and text messages on laboratory completion rates

Radiology Patient Clinical Messages

Advanced Imaging (CT, ultrasound, fluoroscopy, nuclear medicine, bone density and MRI)

For radiology patient clinical messaging, starting in March 2015 we messaged (automated text or automated phone call) all patients on days 1, 8 and 15 if they have had advanced imaging (CT and MRI) orders that have not been completed or scheduled to be completed. Figure 2 shows the impact of radiology patient clinic messages. Radiology patient clinical messages had led to an average increase of 44/month more advanced imaging tests occurring post-implementation (177 total more tests finalized than otherwise expected during the four-month post-implementation period) (and 71/month more advanced imaging tests scheduled; 284 total more tests scheduled than otherwise expected during the four-month post-implementation period). The increase in the number of completed radiology tests has led to ~$10,000 per month in additional radiology revenue.

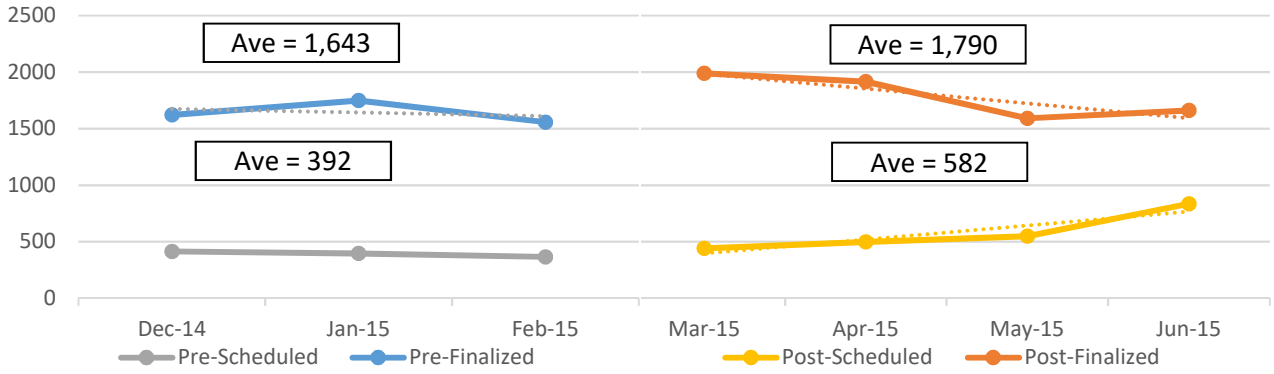


Figure 2 – Pre-Finalized and Pre-Scheduled orders (number and linear trend) versus Post-Finalized and Post-Scheduled orders (number and linear trend), before and after advanced radiology imaging order patient clinical messaging began in March 2015

Breast Imaging (screening mammography, diagnostic mammography and ultrasound)

Starting in March 2015 when a woman who had a personal health record account was ordered a screening mammogram, a diagnostic mammogram or breast ultrasound they received a message in their after visit summary and through their personal health record that the test had been ordered and that they could schedule the test themselves through their personal health

record account. Figure 3 shows the impact of the messaging and ability to self-schedule breast imaging. Personal health record messaging and self-scheduling had led to an average increase of 147/month more breast imaging (586 total more tests finalized then otherwise expected during the four-month post-implementation period) (and 190/month more breast imaging tests scheduled; 586 total more tests scheduled then otherwise expected during the four-month post-implementation period). The increase in the number of completed breast imaging tests leading to ~$5,000 per month in additional radiology revenue.

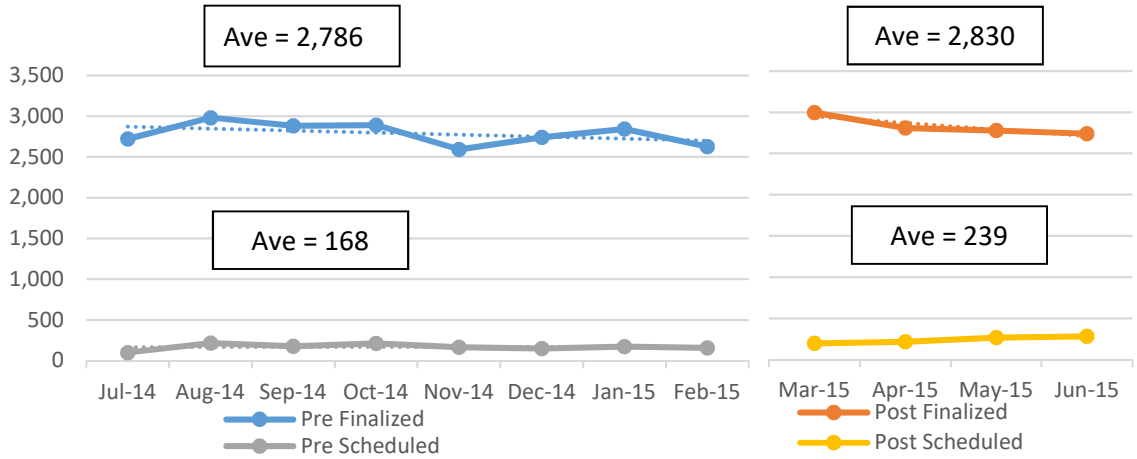
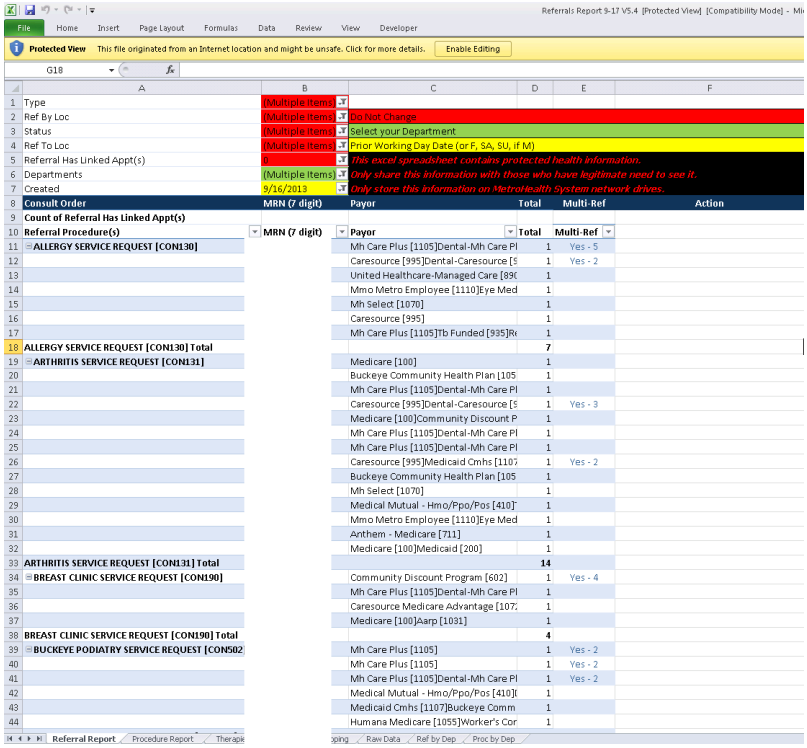


Figure 3 – Pre-Finalized and Pre-Scheduled orders (number and linear trend) versus Post-Finalized and Post-Scheduled orders (number and linear trend) before and after self-scheduling of breast imaging was implemented in the personal health record beginning in March 2015

Health IT Value Example: Internal Referral Completion

Brief Overview

The Internal Referral Completion case demonstrates treatment/clinical care, patient engagement and population management, and revenue generation from the HIMSS STEPS model. In the summer 2011, throughout the MHS, ambulatory patient volume was not meeting expectations. We leveraged our electronic health record (EHR) infrastructure and the fact the as an integrated healthcare delivery network, we are our own biggest source of referrals. Throughout the MHS we identified that only 48% of all of our consult and procedure referrals were completed or scheduled to be completed within 30 days of the referral order being placed into the EHR. In the beginning of 2012, the MHS implemented a system that identifies consult and procedure referral orders placed in the EHR for which the appointment was not complete or scheduled to be completed within 24 hours. These patients lists (Figure 1) are sent every business day to the referred area for them to reach out directly to the referred patients. Recently, the MHS began to convert this semi-manual process into more automated processes using advanced functionality within the EHR including advanced visit types, schedulable orders and referral work queues.



Type	(Multiple Items)				
Ref By Loc	(Multiple Items)	Do Not Change			
Status	(Multiple Items)	Select your Department			
Ref To Loc	(Multiple Items)	Prior Working Day Date (or F, SA, SU, if M)			
Referral Has Linked Appt(s)	0	This excel spreadsheet contains protected health information.			
Departments	(Multiple Items)	Only share this information with those who have legitimate need to see it.			
Created	9/16/2013	Only store this information on MetroHealth System network drives.			

Consult Order	MRN (7 digit)	Payor	Total	Multi-Ref	Action
Count of Referral Has Linked Appt(s)					
Referral Procedure(s)	MRN (7 digit)	Payor	Total	Multi-Ref	
ALLERGY SERVICE REQUEST [CON130]		Mh Care Plus [1105]Dental-Mh Care Pl	1	Yes - 5	
		Caresource [995]Dental-Caresource [9	1	Yes - 2	
		United Healthcare-Managed Care [89(	1		
		Mmo Metro Employee [1110]Eye Med	1		
		Mh Select [1070]	1		
		Caresource [995]	1		
		Mh Care Plus [1105]Tb Funded [935]Re	1		
ALLERGY SERVICE REQUEST [CON130] Total			7		
ARTHRITIS SERVICE REQUEST [CON131]		Medicare [100]	1		
		Buckeye Community Health Plan [105	1		
		Mh Care Plus [1105]Dental-Mh Care Pl	1		
		Caresource [995]Dental-Caresource [9	1	Yes - 3	
		Medicare [100]Community Discount P	1		
		Mh Care Plus [1105]Dental-Mh Care Pl	1		
		Mh Care Plus [1105]Dental-Mh Care Pl	1		
		Caresource [995]Medicaid Cmhs [1107	1	Yes - 2	
		Buckeye Community Health Plan [105	1		
		Mh Select [1070]	1		
		Medical Mutual - Hmo/Ppo/Pos [410](	1		
		Mmo Metro Employee [1110]Eye Med	1		
		Anthem - Medicare [711]	1		
		Medicare [100]Medicaid [200]	1		
ARTHRITIS SERVICE REQUEST [CON131] Total			14		
BREAST CLINIC SERVICE REQUEST [CON190]		Community Discount Program [602]	1	Yes - 4	
		Mh Care Plus [1105]Dental-Mh Care Pl	1		
		Caresource Medicare Advantage [107	1		
		Medicare [100]Aarp [1031]	1		
BREAST CLINIC SERVICE REQUEST [CON190] Total			4		
BUCKEYE PODIATRY SERVICE REQUEST [CON502		Mh Care Plus [1105]	1	Yes - 2	
		Mh Care Plus [1105]	1	Yes - 2	
		Mh Care Plus [1105]Dental-Mh Care Pl	1	Yes - 2	
		Medical Mutual - Hmo/Ppo/Pos [410](	1		
		Medicaid Cmhs [1107]Buckeye Comm	1		
		Humana Medicare [1055]Worker's Cor	1		

Figure 1 – Daily report of referral orders not completed or scheduled to be completed within 24 hours of being ordered

Evidence of Value

During the first year of this initiative a total of 61,939 consults and 18,936 procedures were completed/scheduled to be completed (an average of ~6,700 additional visits per month). A financial analysis evaluated the net revenue per month of these additional visits. Figure 2 shows the number of consult appointments, procedure appointments, and total appointment scheduled based on our referral completion initiative from Week 1 (February 2012) through Week 55 (February 2013). Significant dips can be seen during holiday weeks (week 43 – Thanksgiving and weeks 47 and 48 – Christmas and New Year's).

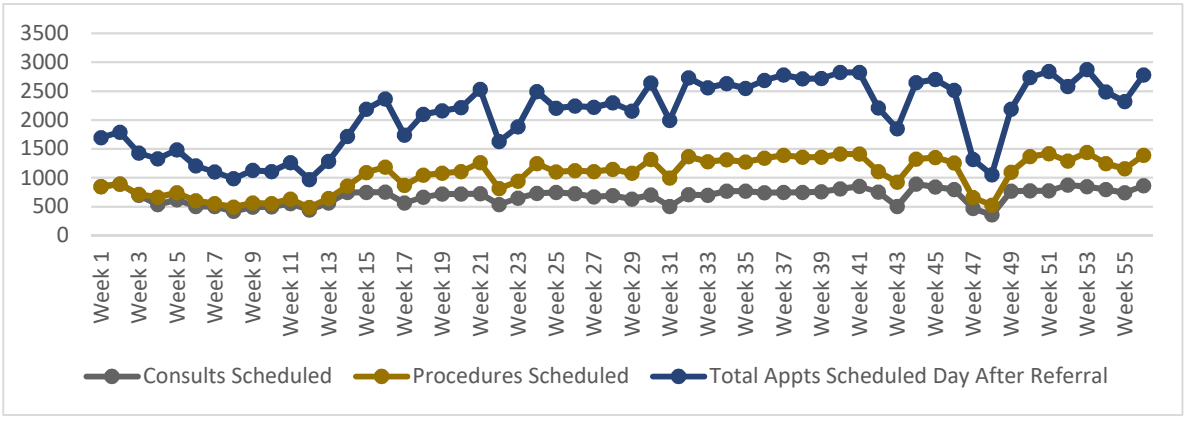


Figure 2 – 56-week analysis of additional consult appointments, procedure appointments and total appointments scheduled through the referral completion initiative

Health IT Value Example: Common High Risk/High Cost Hospital Acquired Infections

Brief Review

The Common High Risk/High Cost Hospital Acquired Conditions case exemplifies treatment/clinical care and costs savings from the HIMSS STEPS model. For over 5 years the MHS has had regular combined Center for Quality and Information Services/Informatics meetings (typically weekly to every other week). One of the primary priorities of having these teams meet has been to implement a range of technology tools to improve (decrease) hospital acquired infections. Over time, these teams have worked on numerous quality related initiatives from an EHR perspective while equivalent teams have worked to address hospital acquired infections from non-electronic health record perspectives. From an electronic health record perspective, primary tools have included:

- Disease/condition specific order sets designed to decrease hospital acquired infections (Figure 1 and Figure 2).
- Best practice advisory designed to decrease hospital acquired infections (Figure 3).
- Improved documentation tools for appropriate care documentation (Figure 4 and Figure 5).

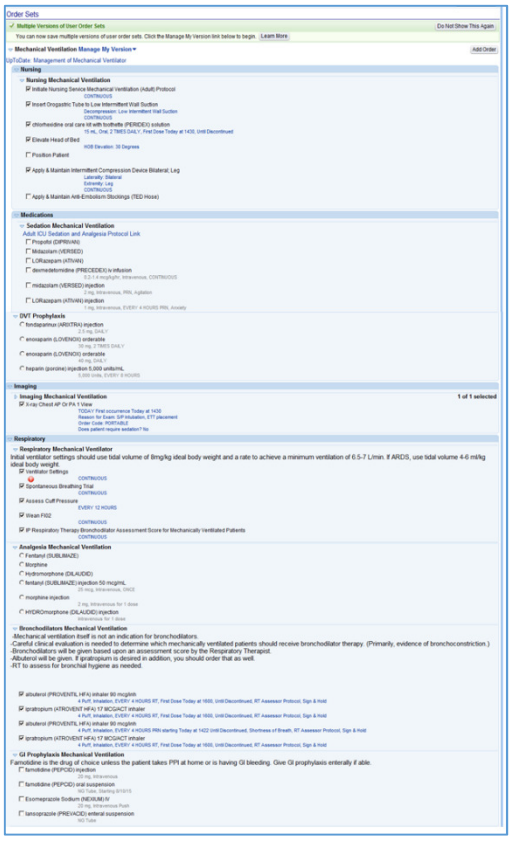


Figure 1 – Electronic health record screen shot of Mechanical Ventilation Order Set implemented 11/2013 as part of EHR strategy to decrease Ventilator Associated Pneumonia rates

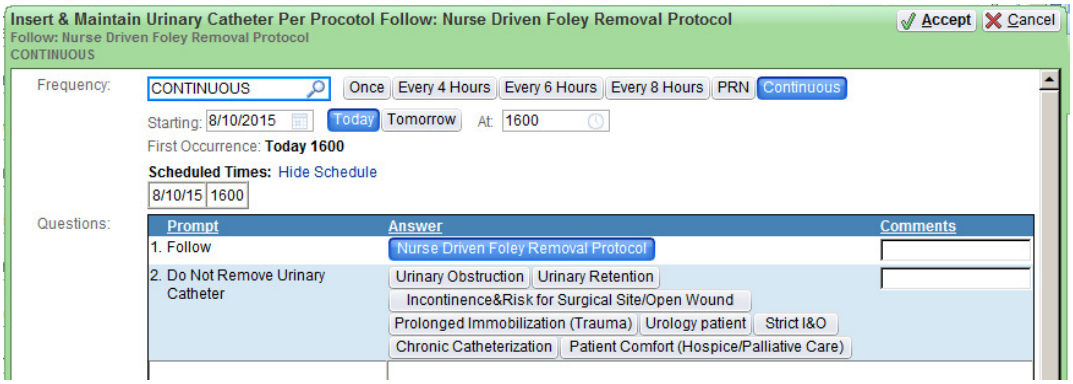


Figure 2 – Electronic health record screen shot of nurse driven Foley removal protocol order implemented 11/2014 as part of EHR strategy to decrease Catheter Associated Urinary Tract Infection rates

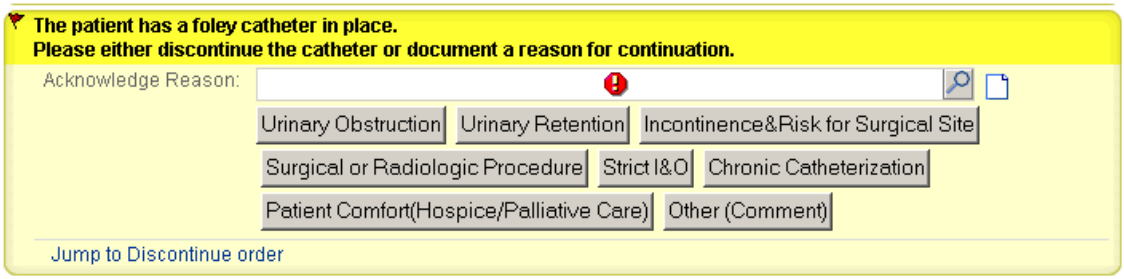


Figure 3 – Electronic health record screen shot of best practice advisory clinical decision support alert to providers implemented 09/2011 as part of EHR strategy to decrease Catheter Associated Urinary Tract Infection rates

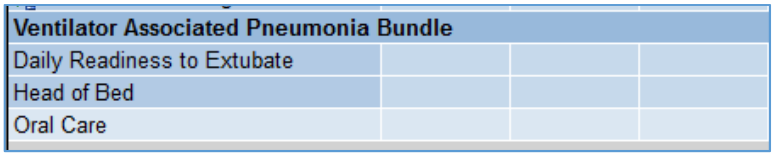


Figure 4 – Electronic health record screen shot of nursing Ventilator Associated Pneumonia documentation tool implemented 04/2013 as part of EHR strategy to Ventilator Associated Pneumonia rates

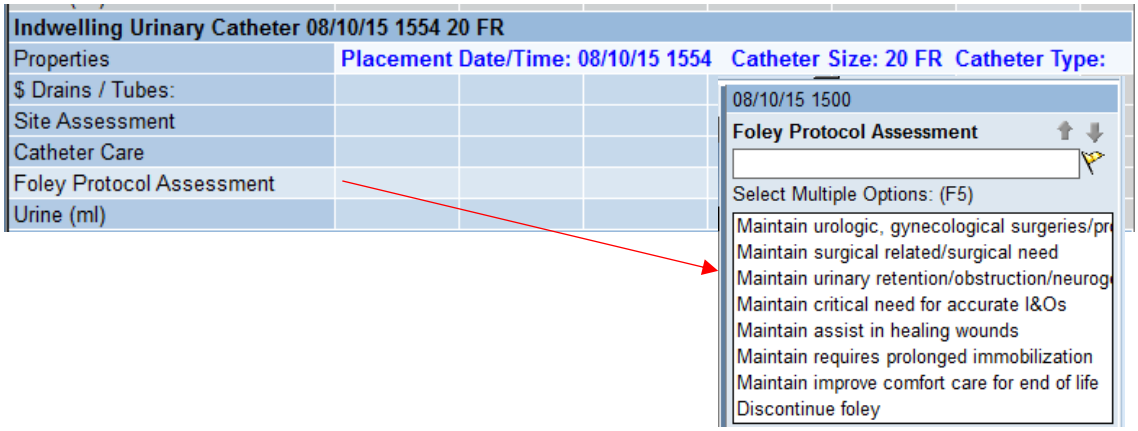


Figure 5 – Electronic health record screen shot of nurse driven Foley removal documentation tool implemented 11/2014 as part of EHR strategy to decrease Catheter Associated Urinary Tract Infection rates

Evidence of Value

Over the last 5 years, efforts that combine electronic health record/technology interventions with non-electronic health record/technology interventions through the working together of various, typically siloed teams (IT/Informatics, quality, nursing, physicians, infection control, respiratory therapy, etc.) have produced significant decrease in catheter associated urinary tract infection (CAUTI) (Figure 6) and ventilator associated pneumonia (VAP) (Figure 7). In the last 5 years, based on all of the CAUTI and VAP infections prevented (Figure 8), these interventions have saved at least several lives and decreased costs by $7.6 million dollars, based on preventing 305 infections at a typical average estimated cost of $25,000 per infection. On an ongoing basis, 102 infection are prevented, $2.6 million dollars are saved and at least one life has been saved.

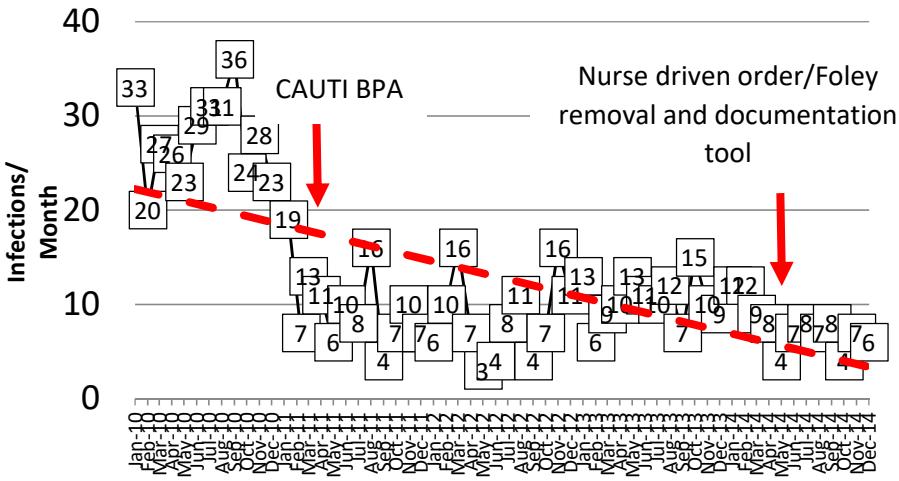


Figure 6 – Trend in catheter association urinary tract infections over time - red arrows indicate EHR tool interventions

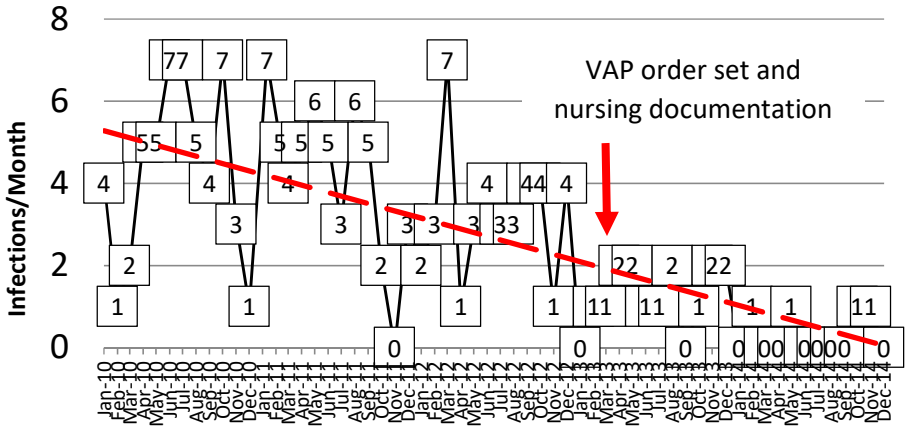


Figure 7 – Trend in ventilator associated pneumonia over time - red arrows indicate EHR tool interventions

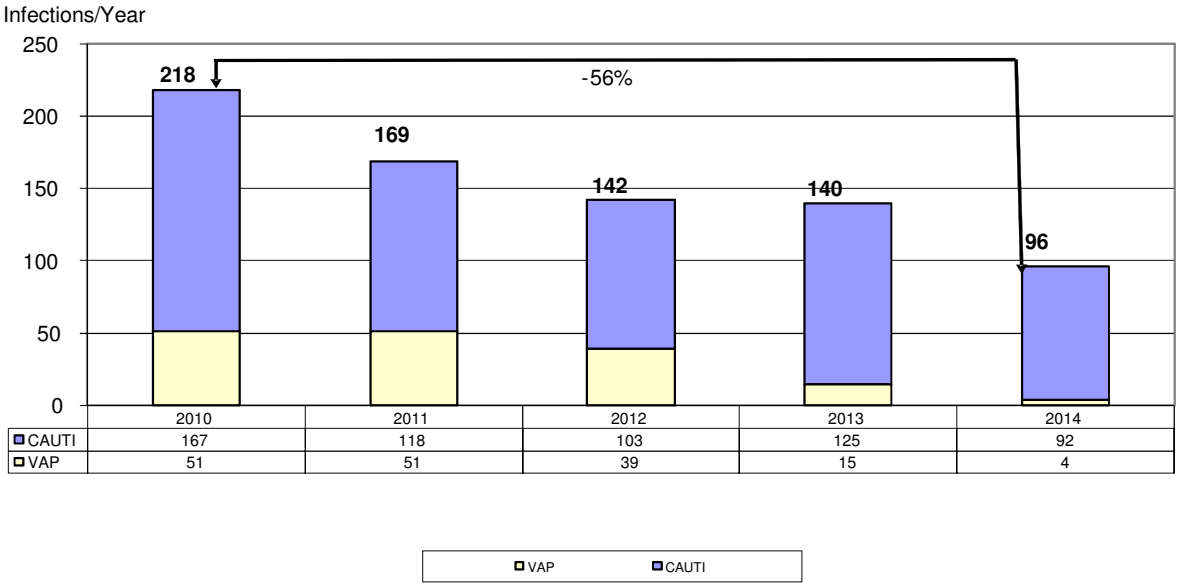


Figure 8 – Overall trends in VAP and CAUTI over time

Health IT Value Example: Improved Core Measures

Brief Review

The Improved Core Measures value example demonstrates the treatment/clinical part of the HIMSS STEPS model. For over 5 years the MHS has had a regular combined Center for Quality and Information Services/Informatics meetings (typically weekly to every other week). One of the primary priorities of having these teams meet has been improvement of The Joint Commission/Centers for Medicare and Medicaid Core Measures. Over time, these teams have worked on Core Measures related initiatives from an EHR perspective, while equivalent teams have worked on Core Measures from a non-EHR perspective. From an EHR perspective, two examples of EHR Core Measures related tools have included:

- Development of smarttext and processes to automatically print appropriate patient discharge instructions for congestive heart failure patients onto printed discharge instructions
- Development and routine use of an alcohol use screening tool for inpatient psychiatric patients

Evidence of Value

Figure 1 and Figure 2 track two core measures over time (one for heart failure and one for inpatient psychiatry) and show the temporal improvement correlated with specific EHR interventions. In the congestive heart failure discharge instructions example, the EHR intervention has provided a sustained 10-15% improvement (86% to over 95% compliance) in the core measure score (Figure 1). In the case of the inpatient psychiatry screening for alcohol abuse example, the EHR intervention has sustained a more then 25% improvement (78% to over 95% compliance) in the core measure score (Figure 2).

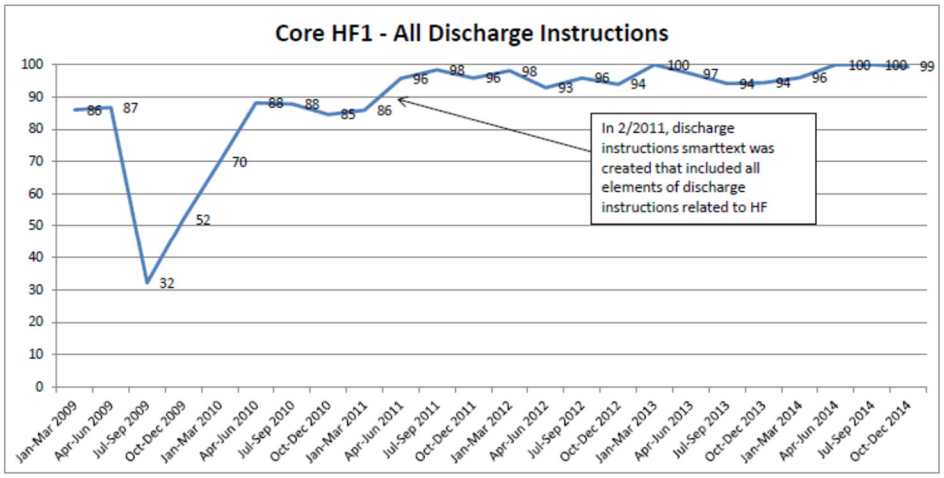


Figure 1 – Heart Failure Core Measure Discharge Instruction measure (HF1) over time (2009-2014) with impact of electronic health record discharge instruction smarttext implemented in the spring of 2011

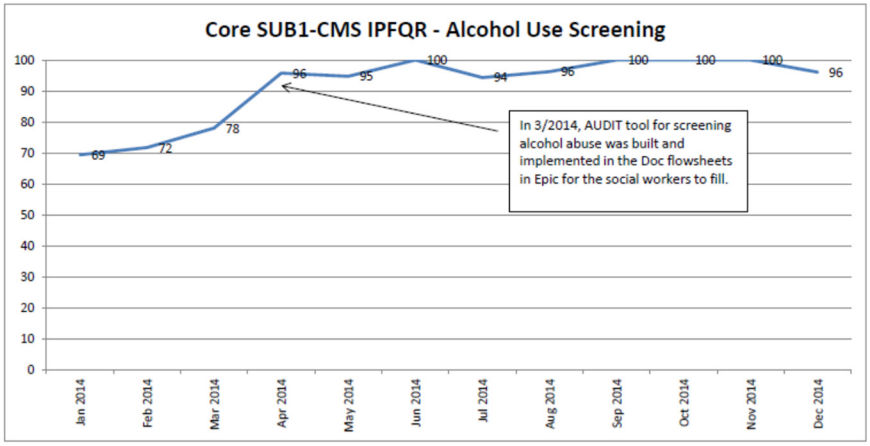


Figure 2 – Inpatient Psychiatric Facility Quality Reporting (IPFQR) Core Measure Alcohol Use Screening measure (IPFQR Sub1) over time (2009-2014) with impact of electronic health record screening tool implemented in the spring of 2014

Health IT Value Example: Blood Pressure Diagnosis Research and Improvement

Brief Review

One early "research" success of the MHS EHR, which exemplifies the treatment/clinical and prevention parts from the HIMSS STEPS model, was the ability take isolated clinical observations and efficiently see if they were generalizable to the larger healthcare system. In 2006, the director of the MHS Pediatric Nutrition, Exercise and Wellness (NEW) Lifestyles Weight Management program had the isolated clinical observation that a significant proportion of the children referred to the Pediatrics NEW Lifestyles Weight Management program appeared to have undiagnosed pediatric hypertension. Two Case Western Reserve University School of Medicine students and an informatics fellow took this clinical observation and were able to efficiently pull data from throughout the MHS EHR to demonstrate that approximately

only 25% of children with blood pressures in the EHR meeting criteria for hypertension have had their hypertension diagnosed (75% undiagnosed). This finding resulted in a landmark JAMA article, *The Underdiagnosis of Hypertension in Children and Adolescents*, which was designated as one of the top 10 research advances in all of stroke and cardiovascular medicine in 2007 by the American Heart Association. The equivalent study in adults shows that approximately 15% of adult hypertension is undiagnosed as well.

Having used the MHS EHR to identify significant opportunities in the diagnosis of pediatric and adult hypertension, MHS clinical informatics staff then undertook, with the help of grant funding from the Kaiser Foundation of Ohio, to develop tools and methods to improve accurate blood pressure readings and diagnosis of hypertension in children and adults. The first critical step to clinical decision support for blood pressure diagnosis was the recognition that there may be inaccuracies in the blood pressure measurement itself which should be identified, with the person entering the blood pressure value immediately notified. The Epic EHR did not have this immediate evaluation and feedback functionality for entered flowsheet rows, so the MHS worked with the Epic Corporation to develop this functionality for all flowsheet rows, which was used for real-time blood pressure entry validation (Figure 1). If blood pressure values continued to be high in the EHR, clinical decision support alerts were also shown to providers highlighting abnormal blood pressures, showing prior blood pressures and identifying potential evidence based next steps for the evaluation and management of abnormal blood pressure (Figure 2 and Figure 3). These "cascading" alerts (at the time of data entry and then at the time of clinical decision making for patient care) were designed to follow the five rights of clinical decision support to the greatest degree possible: the right information, to the right person, in the right intervention format, through the right channel, at the right time in the workflow.

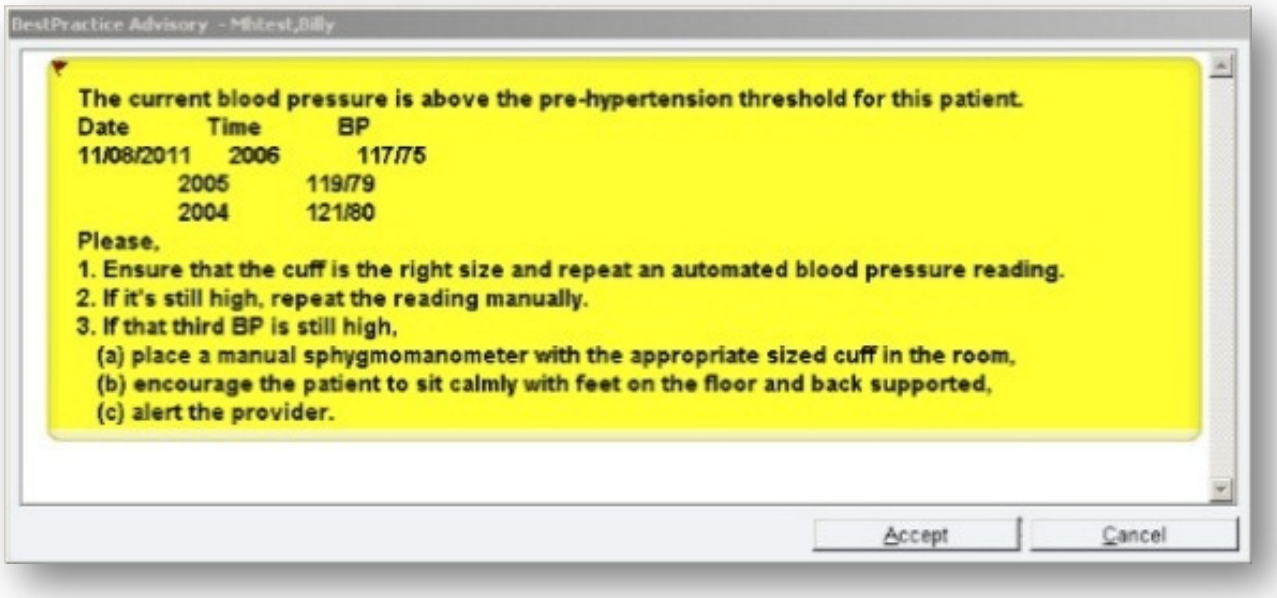


Figure 1 – Electronic health record screen shot of "real-time" clinical decision support alert if an abnormal pediatric or adult blood pressure is entered into the EHR

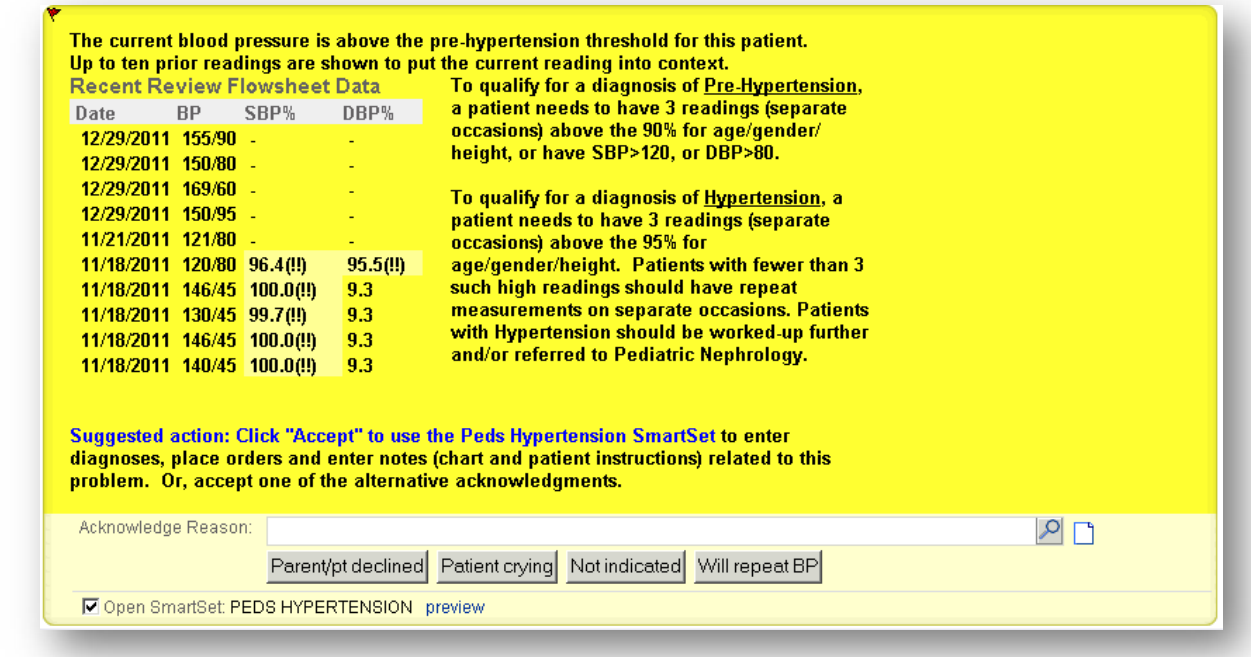


Figure 2 – Electronic health record screen shot of provider clinical decision support (CDS). CDS includes current blood pressure value, prior blood pressure values, hypertension and pre-hypertension definitions and links evidence based orders and guidelines for the diagnosis and management of pediatric hypertension

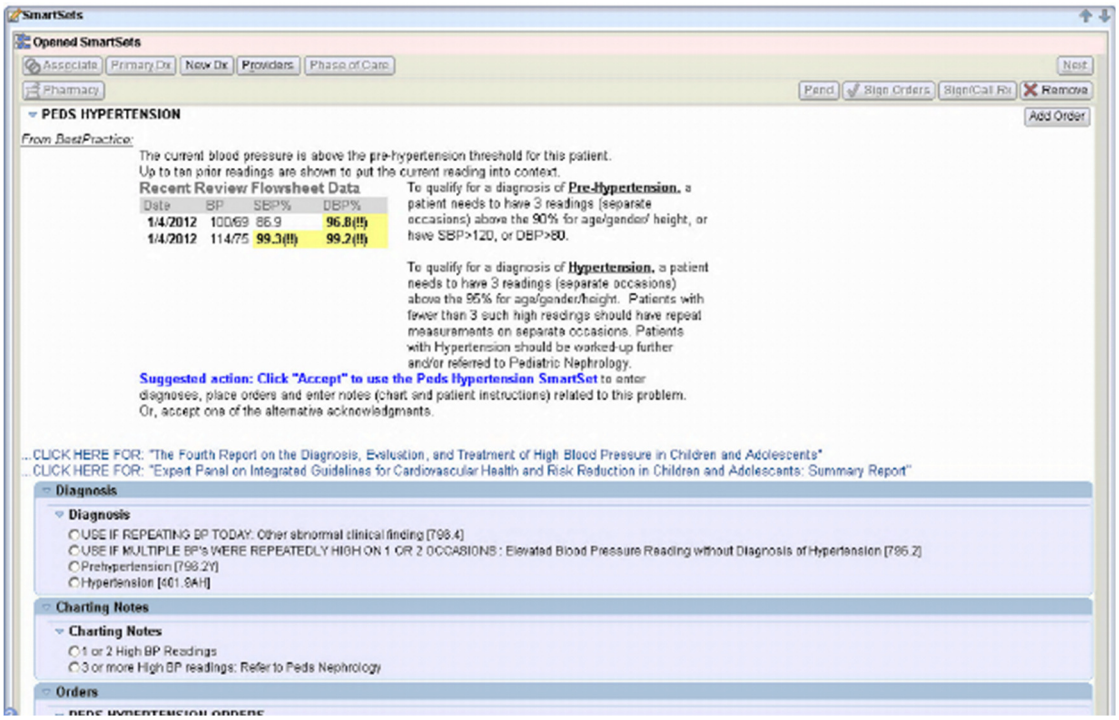


Figure 3 – Electronic health record screen shot of provider clinical decision support with single click evidence based actions for diagnoses, charting notes, and orders for children who appear to have undiagnosed hypertension

Evidence of Value

As expected, the EHR tools had an impact on the quality of the blood pressure data into the EHR as well as the diagnosis of hypertension. Among the pediatric population, 41% of blood pressures initially entered as high ended up being reported as normal. Among the adult population, 21% of blood pressures initially entered as high ended up being reported as normal. Therefore, the "real-time" notification of abnormal blood pressures at the time of data entry into the EHR has a significant impact on the quality of blood pressure in the EHR by causing the blood pressure to be validated, during which time a significant percentage of the blood pressures end up not being abnormal.

Among the pediatric population that has abnormal blood pressure, 58% of the time the abnormal blood pressure was recognized, as opposed to the approximately 25% of the time prior to the pediatric blood pressure diagnoses support being implemented.

Lessons Learned

Over the last 15 years, the MHS has learned that EHRs specifically and HIT generally can be a huge tool for administrative, clinical, financial, operational and quality improvement. However, EHRs/HIT just provides the tool. The potential of these tools will only be realized through focused, ongoing, inter-disciplinary teams with a commitment to continuous improvement.

Key lessons include:

- Although the specific details of projects enhanced/catalyzed by EHRs/HIT will differ, generalizable needs exist across EHR/HIT catalyzed projects including:
    - Dedicated, inter-disciplinary teams
    - Methodology around project governance, project management, project scope and project timelines
    - Standard processes for designing, building, testing, training, implementing and optimizing technology solutions
    - Commitment to plan, do, study, act (PDSA) (or similar) continuous improvement processes

- Need to commit to stay abreast of enhancements/changes in EHR (Epic) functionality
- Need to commit to stay abreast of what other Epic customers are doing
- Need to commit to stay abreast of larger trends in health IT and informatics specifically and healthcare generally
- Aligning EHR/HIT activities/initiatives around the overall clinical, business and academic mission of healthcare system

Core Case Study: Return on Investment

Financial Value: Historical Ambulatory EHR ROI

Executive Summary

The initial decision to begin to install the Epic electronic health record (EHRs) in outpatient clinics throughout the MetroHealth System (MHS) was made in the mid 1990s. Although there were many factors involved in the decision, the CEO at the time, had a vision for the long-term, strategic value of EHRs for healthcare generally and MHS specifically, based primarily on the ultimate hard financial return on investment (ROI) to the MHS. At the time, the pre-implementation business case had a net positive financial ROI seven years after implementation. In 2007, a financial return on investment (ROI) was performed on the MHS's ambulatory Epic EHR implementation that occurred beginning in 1999. The analysis showed a positive hard financial ROI beginning in the fifth year post-implementation.

Other highlights of this analysis include:

- Installation cost was almost $42,000 (in 2015 dollars) per full time equivalent (FTE) provider (very much in line with the EHR incentives provided through the HITECH Meaningful Use program).
- Hard financial benefits occurred in 4 major areas:
    - medical record staff savings
    - transcription savings
    - revenue enhancement, professional
    - revenue enhancement, technical
- Ongoing annual steady-state benefit of ~$9.4 million (in 2015 dollars)
- Ongoing annual steady-state benefit of just over $9,000 (in 2015 dollars)/per FTE provider
- A number of "soft" benefits.
    - Improved quality of care for patients
    - Improved patient safety/decreased errors
    - Reduction in duplicate and unnecessary testing (imaging and labs)
    - Easier access to data for administrative, clinical and research purposes
    - Ability to access the EHR remotely
    - Increased patient loyalty/positive perception of the healthcare system
    - Increased employee loyalty/recruitment
    - Decreased number of malpractice lawsuits
    - Decreased success of plaintiff malpractice lawsuits

This analysis was presented in abstract form at the American Medical Informatics Association Annual Symposium in 2007 - *Ambulatory Electronic Medical Record Payback Analysis 7 years after Implementation in a Tertiary Care County Medical System.*

Local Problem

As a public/esssential healthcare system in the mid 1990s, MHS was a paper-based, HIMSS EMRAM Stage 1 healthcare system, which had only laboratory, radiology and pharmacy information system installed in its inpatient and ambulatory facilities. Clinicians could use the laboratory information system to view results, but otherwise all clinical work revolved around paper and even lab test results were returned on paper.

The MHS clinical, operational and administrative leadership within our integrated healthcare delivery system (in which all providers are employed by the healthcare system) had a vision of an integrated, enterprise-wide EHR as a long-term, key technology investment, critical to providing the most cost-effective, high quality care within the MHS.

Given that the MHS was already an integrated healthcare delivery network and that all providers were already employed by the MHS, an EHR was seen as the "nervous system" to functionally connect all parts and people of the healthcare system together and coordinate all activities in the most effective way. Improved clinical and financial efficiencies, reduced costs and enhanced care quality and patient safety were all seen as opportunities where an EHR could provide significant value.

Design and Implementation

In 1997, when the MHS signed its initial Epic EHR contract, the MHS was the first public/essential health system in the US to begin to install the Epic EHR in the ambulatory setting and employing an EHR for all aspects of ambulatory care was a new concept. Therefore, strong commitment from the EHR vendor and throughout all levels of the MHS was needed for project success. In June 1999, the Epic EHR began to be rolled out in each ambulatory clinic, including scheduling, registration, billing, all clinical (provider and ancillary staff) documentation and computerized physician order entry. The Epic EHR was fully deployed throughout all ambulatory clinics in the MHS by the summer of 2002.

How Health IT Was Utilized

Going from a paper based clinic to a "100%" paperless clinic for all primary administrative, clinical, and operational functions required utilization of health IT for all activities in our ambulatory settings. Charges could be created more efficiently and for all completed visits, clinical notes would now be available and legible, voice transcription was eliminated, and MHS no longer needed a team to move paper records from clinic to clinic and to and from the medical records department. "Digitizing" the MHS clinics allowed for more efficient and effective administrative, clinical and operational processes.

Value Derived

Summary ROI

Prior to implementation, the MHS had estimated a seven-year break-even point based on 1) decrease in medical records personnel costs, 2) decrease in transcription costs, and 3)

enhanced professional and technical revenue. In actuality, the break-even point occurred in year five (Table 1).

Overall Return on Investment	1999	2000	2001	2002	2003	2004*	2005**
Costs ($, millions)							
EHR Operating Expenses ($)		1.0	1.0	1.0	1.1	1.1	1.1
Capital Outlay ($)	21.0						
Benefits ($, millions)							
Medical Record Savings ($)		0.3	0.3	0.4	0.6	0.6	0.6
Transcription Savings ($)		0.6	0.6	0.8	1.2	1.3	1.6
Revenue Enhancement, Professional ($)		0.9	1.8	2.3	2.7	3.4	3.8
Revenue Enhancement, Technical ($)		0.8	1.5	1.7	2.0	2.5	2.8
Total Annual Benefit ($)		2.6	4.2	5.2	6.5	7.8	8.8
Net Gain (Loss) ($, millions)	(21.0)	(19.4)	(16.2)	(12.0)	(6.6)	0.1	7.8

* - break-even year

** - ongoing $7.7 million in net ROI beginning in 2005 (~9.4 million in 2015 dollars)

Table 1 – Summary ROI Table of Cost-Benefit Analysis for EHR Implementation

Decrease in Medical Records Personnel Staff

Prior to the implementation of the EHR in our ambulatory clinics, the MHS had a staff of ~20 medical records personnel whose job was to collect and distribute/redistribute paper medical records between various primary care and specialty clinics and the medical records department. As the EHR was implemented throughout all ambulatory clinics over ~3 years (1999-2002), medical records personnel responsible for moving paper records were eliminated. Savings from their salaries and benefits are shown in Table 2.

Personnel Savings	1999	2000	2001	2002	2003	2004	2005
10 Clerks ($10.17/hr) ($)	n/a	176,209	181,496	186,941	192,549	198,325	204,275
5 Clerks ($10.17/hr) ($)	n/a	n/a	n/a	n/a	96,566	99,463	102,447
2 Messengers ($9.60/hr) ($)	n/a	n/a	n/a	35,343	36,404	37,496	38,621
1 Supervisor ($18.34/hr) ($)	n/a	31,777	32,730	33,712	34,723	35,765	36,838
1 Manager ($30.00/hr) ($)	n/a	n/a	n/a	n/a	56,971	58,680	60,441
Total Salaries	**n/a**	**207,986**	**214,226**	**255,996**	**417,213**	**429,729**	**442,621**
Benefits ($)	n/a	33,278	34,276	40,959	66,754	68,757	70,819
Health Care ($)	n/a	51,227	42,108	60,372	85,006	89,091	96,140
Total Salaries and Benefits ($)	**n/a**	**292,491**	**290,610**	**357,327**	**568,973**	**587,577**	**609,581**

Table 2 - EHR Savings: Medical Records Personnel

Decrease in Transcription Costs

Embedded as part of the project plan with the ambulatory EHR implementation was requiring all providers to document into the EHR. The MHS would stop paying for transcription for all staff providers for outpatient visit documentation once the EHR had been installed in their ambulatory clinic. Over the course of the EHR deployment throughout the MHS, elimination of transcription resulted in over $1 million of annual savings (Table 3).

Value in $ (in millions)	1999	2000	2001	2002	2003	2004	2005
Outpatient Volume Growth (%)	n/a	14.6%	1.4%	4.7%	3.4%	3.3%	4.8%
Projected Transcription Costs ($)	n/a	1.5	1.5	1.6	1.7	1.9	2.0
Actual Transcription cost ($)*	1.2	0.9	0.9	0.8	0.6	0.5	0.4
Total Transcription Savings ($)	**n/a**	**0.6**	**0.6**	**0.8**	**1.2**	**1.3**	**1.6**

*Transcription cost from paid vendor report 1999 -2006.

Table 3 - EHR Savings: Transcriptions

Enhanced Professional and Technical Revenue

One of the key financial drivers for the ambulatory EHR implementation was the belief that with an EHR, professional and technical charges (and therefore revenue) would increase through a combination of more favorable coding mix and more complete billing. The EHR would allow for more efficient, appropriate and complete documentation which would result in providers appropriately documenting and billing at higher billing codes. Also, the EHR would allow for transparency of services that were provided but not billed so that bills could be generated for these services. Table 4 summarizes the annual revenue enhancement attributed to the ambulatory EHR implementation. Figure 1 shows the shift in common CPT codes attributed to the ambulatory EHR implementation.

Revenue	1999	2000	2001	2002	2003	2004	2005
Professional							
Annual Impact, $, millions (% inc.)**	n/a	0.6 (4%)	1.5 (11%)	1.9 (14%)	2.3 (17%)	3.0 (22%)	3.4 (25%)
Lost Charge Capture (5% increase) ($)***	n/a	0.3	0.3	0.4	0.4	0.4	0.4
Technical							
Annual Impact, $, millions (% inc.)****	n/a	0.5 (5%)	1.1 (11%)	1.3 (14%)	1.6 (17%)	2.1 (22%)	2.4 (25%)
Lost Charge Capture (5% increase) ($)***	n/a	0.3	0.4	0.4	0.4	0.4	0.4
Total Coding Mix Impact ($ millions)	n/a	1.7	3.3	4.0	4.6	5.9	6.4

* - among Medicare and Medicaid patients which made up ~50% of all patients during the study period

** - compared to 1999 professional revenue baseline

*** - 5% volume increase estimated for previous lost charges/unreported paper billing cards

**** - compared to 1999 technical revenue baseline

*Table 4 - EHR Revenue – Enhanced Revenue from EHR due to Evaluation and Management Coding Mix Impact and Decrease in Unbilled Visits**

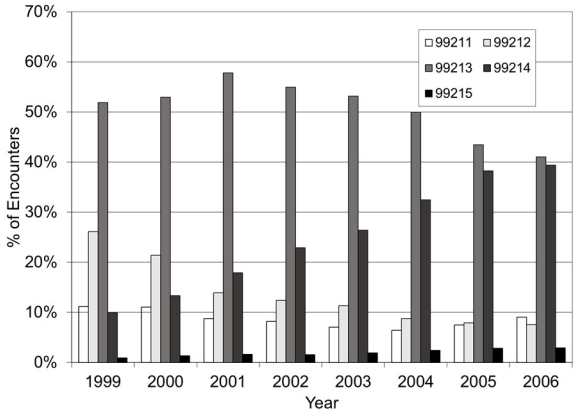


Figure 1 - Common Procedural Terminology Evaluation and Management Coding Mix 1999-2006 Among Most Common Codes

Lessons Learned

As an early adopter of EHRs in our ambulatory setting more than 15 years ago, the MHS learned several key lessons that have continued to allow the MHS to be a leader in exploiting HIT to improve health in support of the MHS's overall vision to "be the most admired public health system in the nation, renowned for our innovation, outcomes, service and financial strength."

Key lessons included:

1. HIT investment/strategy must be clearly tied to corporate/healthcare system vision/mission
2. Strong support of key administrative and clinical executive leaders, especially CEO and CMO is critical
3. Cultural fit and long-term partnership commitment with EHR vendor is imperative ("selecting, implementing, and maintaining/optimizing an EHR is like a marriage" – paraphrase of Epic CEO)
4. Planning is important, but problems/issues will arise pre and post go-live, so adaptability and responsiveness when problems/issues arise is at least (and probably more important) then the initial plan

Financial Value: Last Five years EHR ROI

Executive Summary

Included here is a financial analysis of the most recent five completed fiscal years (2010-2014) of the costs, benefits and overall return on investment (ROI) of the MHS Epic (EHR). The Epic EHR was already fully deployed for all inpatient and outpatient care during this period. However, the operating room, ADT (admission, discharge and transfer), bed tracking, laboratory, health information exchange, personal health record, e-prescribing and hospital billing components of Epic were deployed during this most recent five-year period.

This analysis shows a positive ROI for the EHR in every year of 2010-2014, on average just over $20 million per year, with ongoing estimated positive ROI of just under $20 million per year.

Other highlights of this analysis include:

- Federal incentive programs (Meaningful Use, PQRI/PQRS, e-prescribing) provided over $36 million in hard financial benefits related to EHR ROI
- Even without federal incentive programs, net ROI for the EHR would have been positive.
- Hard financial benefits begin being realized at the time of implementation
- Soft financial benefits accrue slowly after implementation and are not fully realized at the time of implementation
- Soft financial benefits increased by almost an order of magnitude
- Soft financial benefits increased from ~10% of total benefits to ~30% of total benefits
- Even without soft financial benefits (and federal incentive programs), net EHR ROI is positive

Local Problem

Over the first decade (1999-2009) of the MHS's EHR deployment, activities focused on basic implementation, adoption and optimization of the Epic EHR in all inpatient, outpatient and emergency department clinical areas. Over the last five years (2010-2014), significant focus shifted to novel applications and uses of an integrated EHR throughout the MHS's integrated healthcare delivery system. The MHS wanted to tackle system-wide issues confronting the MHS, leveraging its 10-year investment and enterprise deployment of its Epic EHR tool. Significant opportunities existed in the areas of quality improvement, patient engagement, clinical efficiency and overall enterprise intelligence. In addition, the MHS wanted to fully leverage its EHR investment in order to participate in governmental financial incentive programs (PQRS, e-prescribing, and Meaningful Use) and its academic mission.

Design and Implementation

The MHS has a history of understanding that successful efforts involving health information technology require several key characteristics:

1. Team approach – multi-disciplinary team involving informatics services and information staff in addition to key non-technical stakeholders (for example operations staff, quality staff, nursing, physicians, etc., depending on the effort)
2. Clear objectives/project plan – clear understanding of the outcomes desired and the project plan
3. Plan Do Study Act (PDSA) cycles – a clear process to evaluate outcomes and if overall objective(s) not achieved, a commitment for repeated PDSA cycles until objective(s) achieved (or until objectives deemed unachievable or of a less/lower priority)

How Health IT Was Utilized

As the MHS has matured in its EHR understanding, the MHS has come to see the EHR as a complex and powerful tool. As with any tool, having the tool is necessary, but not sufficient by itself to change/improve processes and outcomes. Rather, as ideas/opportunities for improvement arise, the MHS's approach is to:

1. Analyze Existing EHR solutions – determine if EHR solutions exist, either within the MetroHealth EHR system or among other Epic customers or on the Epic UserWeb)
2. Develop EHR solutions – determine if the building blocks exist with the Epic EHR tools to develop EHR solutions
3. Design/Build/Test/Train – assuming a solution exists or could built using existing EHR tools, have an inter-disciplinary team design, build, test and train for the use of the solution
4. Evaluate – evaluate the effectiveness of the solution to address the root idea/opportunity

Value Derived

Summary Total ROI

Table 1 summarizes the overall ROI for our EHR over the last five years, including capital and operating budgets related to the MHS's EHR as well as significant quantified hard and soft financial benefits (2010-2014).

IS EHR/Core Clinical Systems*	2010 ($, millions)	2011 ($, millions)	2012 ($, millions)	2013 ($, millions)	2014 ($, millions)	Average ($, millions)
Capital Costs	n/a	1.2	1.9	8.2	4.2	3.9
Operating Costs	4.2	5.1	5.7	7.5	9.4	6.4
Hard Financial Benefits	9.8	33.3	30.8	31.4	30.1	23.1
Soft Financial Benefits	1.6	2.0	3.5	5.8	10.7	4.7
TOTAL (net)	7.2	29.0	26.7	21.5	27.2	111.6**

* - core clinical systems include the Epic electronic health record and all related installed modules, Hyland/OnBase related clinical scanning products, laboratory information systems and radiology information systems

** - total net over 2010-2014 (ongoing annual estimated, not inflation adjusted, net $19.2 million)

Table 1 – Overall EHR/Core Clinical Systems ROI (2010-2014)

Summary Financial Costs Breakdown

Table 2 shows overall healthcare system and information services capital and operating budgets (2010-2014).

Table 3 shows IS EHR and related core clinical systems capital costs (2010-2014).

Table 4 shows IS EHR and related core clinical systems operating costs (2010-2014).

Overall	2010 ($, millions)	2011 ($, millions)	2012 ($, millions)	2013 ($, millions)	2014 ($, millions)	Average ($, millions)
MHS Capital Budget	**19.0**	**26.7**	**29.8**	**52.4**	**35.6**	**32.7**
IS Capital Budget	n/a	2.2	2.9	9.2	5.2	4.9
% IS/System (Capital)	n/a	8.11%	9.57%	17.50%	14.63%	12.45%
MHS Operating Budget	700.1	760.2	776.9	823.9	858.5	784.0
IS Operating Budget	19.6	21.4	23.7	27.8	33.0	25.1
% IS/MHS (Operating)	2.79%	2.81%	3.05%	3.37%	3.85%	3.2%

Table 2 – Overall healthcare system and information services capital and operating budgets (2010-2014)

EHR/Core Clinical Systems* Capital Costs	2010 ($, millions)	2011 ($, millions)	2012 ($, millions)	2013 ($, millions)	2014 ($, millions)	Average ($, millions)
Hardware	n/a	0.59	0.35	3.20	1.65	1.45
Software/Licensing	n/a	0.45	0.13	3.51	1.70	1.45
Interfaces	n/a	0.13	0.15	0	0.24	0.13
Staffing	n/a	0	1.23	1.47	0.62	0.83
TOTAL	**n/a**	**1.17**	**1.86**	**8.18**	**4.21**	**3.86**

* - core clinical systems include the Epic electronic health record and all related installed modules, Hyland/OnBase related clinical scanning products, laboratory information systems and radiology information systems

Table 3 – EHR/Core Clinical Systems Capital Costs (2010-2014)

EHR/Core Clinical Systems* Operational Costs	2010 ($, millions)	2011 ($, millions)	2012 ($, millions)	2013 ($, millions)	2014 ($, millions)	Average ($, millions)
Hardware Replacement	n/a	0.04	0.04	0.50	0.29	0.22
Software Updates/Licenses	1.12	1.79	2.02	2.04	2.89	1.97
Staffing	2.92	2.90	3.29	3.87	5.21	3.64
Training	0.03	0.07	0.11	0.16	0.14	0.10
Consulting	0.17	0.25	0.24	0.96	0.84	0.49
TOTAL	**4.24**	**5.05**	**5.70**	**7.53**	**9.37**	**6.38**

* - core clinical systems include the Epic electronic health record and all related installed modules, Hyland/OnBase related clinical scanning products, laboratory information systems and radiology information systems

Table 4 – EHR/core clinical systems operating costs (2010-2014)

Summary Financial Benefits Breakdown

Hard Financial Benefits Breakdown

Table 5 shows major hard financial benefits attributable to the MHS from the EHR (2010-2014). Details of the Continued Annual Ambulatory EHR ROI are described earlier in the Financial Core Case Study. Details of the Automated Patient Clinical Messaging and Referral Completion ROI are described in the Clinical Care Core Case Study.

US (Federal) EHR Incentive Programs

One the benefits of being an early adopter of the Epic EHR is the relative ease with which the MHS has been able to participate in federal EHR incentive programs. Typically successful participation has involved configuring and/or turning on and educating end users about features and functions that were already possible within the EHR. The MHS has participated in the Meaningful Use program as well as CMS's eRx and PQRS/PQRI programs. As more providers became eligible for Meaningful Use and the MHS became a Medicare Shared Savings ACO (2013), MHS is no longer eligible for the CMS eRx and CMS PQRS programs. Income from these Federal EHR Incentive Programs appears in Table 5.

EHR Related Grants

As an academic health system affiliated with Case Western Reserve University's School of Medicine, the MHS valued the EHR as an academic research tool. Over the last 15 years more than 20 grants from governmental and non-governmental agencies have been obtained by the MHS that would have been impossible to obtain without the EHR. EHR related grants fall into two primary categories – grants to do primary EHR related research and grants that leverage the breadth and depth of data in the EHR to perform the research. Some grants combine these two categories. Income for EHR related grants appears in Table 5.

Hard Financial Benefits	2010 ($, millions)	2011 ($, millions)	2012 ($, millions)	2013 ($, millions)	2014 ($, millions)	Annual Ongoing* ($, millions)
Ambulatory EHR ROI	8.9	9.0	9.1	9.2	9.3	9.3
Automated Patient Clinical Messaging	n/a	n/a	0.3	0.6	0.7	0.7
Referral Completion	n/a	12.0	12.0	12.2	12.4	12.4
US EHR Incentive Programs						
Meaningful Use	*n/a*	*11.2*	*8.5*	*8.6*	*7.0*	*Variable*
CMS eRx	*n/a*	*n/a*	*0.1*	*0.1*	*0*	*n/a*
CMS PQRS	*0.3*	*0.3*	*0.2*	*0.1*	*n/a*	*n/a*
EHR Related Grants	0.6	0.8	0.6	0.6	0.7	0.7
TOTAL	**9.8**	**33.3**	**30.8**	**31.4**	**30.1**	**23.1**

* - unadjusted for inflation

Table 5 – Hard financial benefits attributable to the MHS from the EHR

Soft Financial Benefits Breakdown

Table 6 shows IS EHR and related core clinical systems capital costs (2010-2014). Details of the Health Information Exchange and High Risk/High Cost Hospital Acquired Infections ROI are described in the Clinical Case Core Case Study. Details of the MRDO/*Acinetobacter* ROI are described in the Menu Case Study: MDRO/*Acinetobacter*.

Soft Financial Benefits (Cost Savings/Avoidance)	2010 ($, millions)	2011 ($, millions)	2012 ($, millions)	2013 ($, millions)	2014 ($, millions)	Annual Ongoing* ($, millions)
High Risk/High Cost Hospital Acquired Infections (CAUTI, VAP)	n/a	1.2	1.9	2.0	2.6	2.6
Ambulatory Diabetes Care	0.2	0.2	0.3	0.8	0.9	0.9
MRDOs/*Acinetobacter*	1.3	0	0.4	0.3	2.3	1.0
Infectious Diseases (HIV/HCV) Screening	0.1	0.2	0.2	1.9	3.5	3.5
Personal Health Record (MyChart)	n/a	0	0.3	0.5	0.9	1.1
Health Information Exchange	0	0.4	0.3	0.2	0.3	0.3
Duplicate/Lifetime Testing Clinical Decision Support	0	0	0.1	0.1	0.2	0.3
TOTAL	**1.6**	**2.0**	**3.5**	**5.8**	**10.7**	**9.7**

* - unadjusted for inflation

Table 6 – Soft financial benefits attributable to the MHS from the EHR

Duplicate/Lifetime Testing Clinical Decision Support (CDS)

Beginning in 2010, the MHS has used embedded clinical decision support (CDS) to try to identify and curb inappropriate lab ordering by providers. Duplicate urine culture was the first attempt

in this area. An alert was built to notify the ordering provider at the time of ordering that another urine culture had already been ordered in the last 48 hours. When alerted with this CDS, 52% of the time the provider cancelled/did not complete the duplicate urine culture order (Figure 1). This alert is estimated to save ~$15,000/year in decreased duplicate ordering of urine cultures within 48 hours, which typically occurs among hospitalized patients.

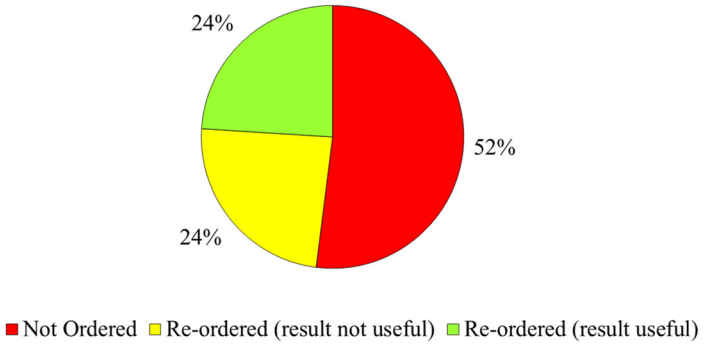


Figure 1 – Result of clinical decision support on duplicative urine culture order

Since this initial experience, other laboratory CDS has been put in place (Table 7).

Laboratory Clinical Decision Support Area
Duplicate urine culture testing within 24 hours
Duplicate blood culture testing within 24 hours
Duplicate *Clostridium Difficile* testing within 72 hours
Once in a lifetime methylenetetrahydrofolate redutase
Once in a lifetime pro-predict thiopurine methyltransferase
Once in a lifetime Prothrombin gene
Once in a lifetime Factor V Leiden
Once in a lifetime HLA B57
Once in a lifetime HLA 27
Once in a lifetime Hemochromatosis DNA

Table 7 – List of current laboratory CDS

Savings related to these efforts are shown in Table 6.

Personal Health Record (MyChart)

The MHS went live with the Epic personal health record (MyChart) in the fourth quarter of 2011, with all providers participating. MyChart initially started with a limited number of administrative (outpatient lab and immunization viewing) and clinical functions (provider, renewal and referral messaging). Over the last five years, the MHS has continued to enhance administrative and clinical functions available through MyChart. Table 8 shows primary features currently live in MyChart.

Administrative MyChart Functions	Clinical MyChart Functions
Schedule requests for all appointments	Medical advice requests
Address/insurance change self-service	Medication renewal requests
Self-Scheduling for follow-up appointments	Viewing all lab results (auto-released)
After Visit Summary viewing	Viewing all radiology results (auto-released)
Referral requests	Viewing all immunizations
Request complete medical record	Growth chart viewing (pediatrics)
Bill-pay	Patient entered BP, blood sugar, and weight
Administrative pre-check-in (pilot)	Pre-visit symptoms questionnaires
Request account and password self-service	Video visits (pilot)
Customer service request	Open Notes (provider opt-in)

Table 8 – Primary MyChart features broken down by administrative and clinical features

Figure 2 shows the growth of MyChart over the last five years in terms of total patients enrolled.

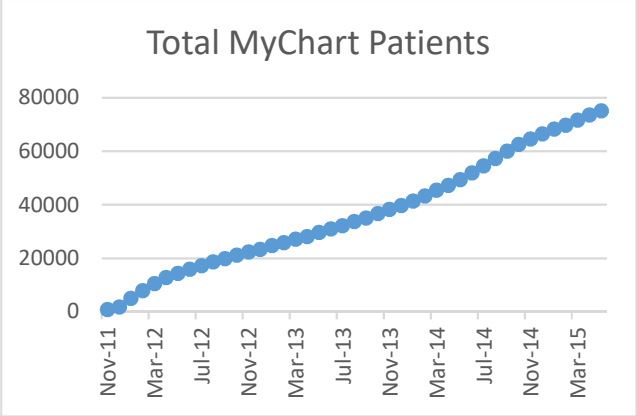


Figure 2 – Total patients enrolled in MyChart over time

Currently ~40% of MHS patients are enrolled in MyChart and the current plan and trajectory should have more than 50% of patients enrolled by the end of 2016.

Table 9 shows total overall use statistics for MyChart as of June 2015. From a financial ROI perspective, soft dollars can be attributed to test, letter and immunization viewing (avoided phone call from patient to answer and/or letter to patient to send) (estimate of $1 per viewing, discounted 50% from total number because of possible multiple viewings of the same results). Self-scheduling alleviates MHS staff from the scheduling process and we have shown it decreases the no-show rate by ~25% among patients who self-schedule (estimate of $2.50 in cost savings per self-scheduled appointment). Advice requests, referral requests, renewal requests, appointment schedule, and patient entered flowsheets all provide the potential for more efficient (both on the provider and healthcare system side) asynchronous workflows then the equivalent synchronous (typically phone call based) processes (estimated $0.50 per use, discounted 50% from total number because some patients still calling/needed to call after attempting the MyChart work flow for these functions). Using these three soft financial ROI methodologies the breakdown of ROI for MyChart appears in Table 6.

MyChart Function	Total Usages	Ave. Use/Day	Unique Users
Login	2,929,984	1,655	70,778
Test Viewing	3,455,975	1,952	68,116
Letter Viewing	1,302,429	735	48,074
Immunization Viewing	550,226	311	62,564
Advice Request	546,683	308	42,378
Medication Renewal	281,432	159	37,260
Appointment Schedule	256,459	145	36,016
Proxy	202,365	114	18,161
Referral Request	39,949	23	13,096
Patient Entered Flowsheet	30,324	17	179
Self-Scheduled Appointment	4,327	46	2,657
TOTAL	**30,502,064**	**17,233**	**380 (ave hits/user)**

Table 9 – MyChart usage statistics

Lessons Learned

Even a decade after initial EHR implementation, and now with a single vendor EHR deployed throughout the MHS, numerous opportunities continue to exist for the EHR to provide additional ROI. Realizing these opportunities requires a continued systematic approach and interdisciplinary teams to identify and implement solutions to provide value, based on expanding existing EHR functionality, new EHR functionality and new healthcare system opportunities and priorities.

Key lessons included:

1. Hard and soft financial benefits need to be actively and aggressively sought out to provide a positive net ROI for EHR implementation
2. Implemented appropriately, a net positive EHR ROI can be obtained only based on hard financial benefits
3. Federal EHR incentive programs and soft financial benefits are not needed to obtain a net positive EHR ROI
4. Numerous opportunities exist for soft financial benefits but need to be thought of creatively and with a focus on soft financial ROI
5. The value of soft financial benefits typically grows significantly over time (as opposed to hard financial benefits which are typically realized immediately)
6. There should be clear understanding to whom soft financial benefits are going, especially as reimbursement models for healthcare change

MetroHealth System Selected Bibliography of EHR Related Publications and Abstracts

Publications

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Menu Case Study: Ambulatory Diabetes Care

Executive Summary

The MetroHealth System (MHS) is the primary care provider for over 10,000 adult patients with diabetes, which is one of the top ten adult diseases associated with morbidity and mortality in the US, and causes billions of dollars in annual healthcare costs. Over the last decade, MHS has deployed a number of electronic health record (EHR) features as part of its overall programs and strategies to improve the care of adult diabetic patients. EHR-based initiatives designed to improve the care of diabetic patients included:

- EHR report generated and standing order for pneumonia vaccines (for diabetic and non-diabetic patients) (2003)
- Standardized EHR reports of diabetic patients for each provider (beginning 2005; updated 2013)
- Diabetic patient clinical decision support (best practice alerts and health maintenance reminders) (initial 2005; revised 2007)
- Diabetic patient care plans (2010 by letter; 2012 by goals, barriers and interventions)
- Diabetic foot exam and eye exam discrete documentation tools (2011)
- Regular comparative reports showing how each provider compares to others on key diabetes performance measures (2009) and then tied to financial quality incentives (2011)
- Diabetes "Synopsis reports" (which summarizes diabetes care for a given patient) (2012)

Effectiveness measures were broken down in two groups – more care process/MD-centric measures (diabetic eye exam rates, pneumococcal vaccination rates, monitoring or treating kidney impairment with appropriate angiotensin converting enzyme (ACE) inhibitors or angiotensin receptor blockers (ARBs), checking hemoglobin A1C (HbA1c) and control of cholesterol through LDL ≤100mg/dl or patient being on a statin cholesterol-lowing medication) and more outcome/patient-centric measures (achieving optimal glycemic control (HgA1C <7%), blood pressure <130/80 mmHg, body mass index <30 and not smoking).

Overall, over the ten year period, process and outcome composite measures improved over 30%, with outcomes composite measure improvement lagging several years behind process composite measure improvement. These changes in care caused an estimated 10% decrease in the costs of care for diabetic patients. As these EHR tools are very scalable across MHS and are applied across the population of all of the over 10,000 diabetic patients, the cost savings is approximately $1 million per year.

Local Problem

In the mid 2000s, the MHS identified diabetes as a major adult chronic disease that consumes significant resources and leads to significant patient morbidity and mortality. The MHS also recognized that significant value (quality/cost) improvement opportunities probably existed in the care for diabetic patients and that these value opportunities could probably be catalyzed be the EHR.

The challenge was to develop the people, processes and cultural changes needed to use the EHR in continuing processes to improve the value (increase the quality of care and/or decrease the cost of care) of care for diabetic patients.

Design and Implementation

Funded for the first two years (2005-2006) through an Agency for Health Research and Quality as the Diabetes Improvement Group-Intervention Trial initiative and then funded as a Robert Wood Johnson Foundation Regional Quality Improvement Collaborative (2007-2014) which has now become the Better Health Partnership (http://www.betterhealthpartnership.org/), the long-term effort to improve diabetes care brought together health services researchers, clinical informaticians, information services staff, statisticians, clinicians and support staff. These individuals, sometimes changing over the last decade, have met in clinical and technical standing committees and various "ad hoc" work groups to design, build, test, train, implement and evaluate all of the measures and tools used to improve diabetes care.

Once the representatives were identified, teams met and agreed on (and adjusted over time) the evaluation measures (care process and outcomes) for outpatient diabetic care. Once the conceptual measures were agreed to, details of the specific EHR elements to define the measures were determined and regular data extraction, analysis and reporting occurred, which continues today. This allowed the group to establish a baseline of adult diabetes measures and to track these measures over time as various EHR tools were implemented.

In parallel to the diabetes measure development, teams began to identify potential EHR tool enabled work-flow changes that could improve diabetes care and outcomes. Over time, seven different tools have been implemented and revised to date. The tools implemented generally fall into three categories 1) decision support tools for evidence based best practice diabetes care, 2) documentation tools to document appropriate care and care plans, 3) reports (at the patient, provider and system level) to summarize diabetic care provided and eventually tied to financial incentives for providers.

How Health IT Was Utilized

Health IT was used in a number of ways to continuously support the care of diabetic patients throughout the MHS ambulatory clinics. The continued commitment to EHR based tools over the last decade has led to an average of one new tool per year.

Initial tools (2005) focused on best practice alerts (Figure 1), first without the ability to easily order the evidence items recommended, and then next generation best practice alerts (2007) (Figure 2) which allow easy ordering of evidence items recommended.

Another early focus of EHR tools for diabetic care support for providers was provider level reports showing key characteristics for all of their diabetic patients in a single report (2005,

revised 2013) (Figure 3 and Figure 4). Over time, additional reporting included comparative reports where a provider could compare their performance to peers (2009). Next, financial incentives were tied to comparing performance metrics (2011).

Additional EHR tools were built to capture structured data for diabetic care documentation (foot exams and eye exams) (2011).

Care plan tools were also built to clearly capture diabetic care plans. These tools allow diabetic care plans to be clearly identified and tracked over time, as well as communicated to patients (initial version 2011 and updated version 2013).

In 2012, the MHS also implemented Epic's synopsis tool for diabetes. This tool provides a longitudinal picture at a patient level of important metrics related to a patient's diabetes over time (Figure 5).

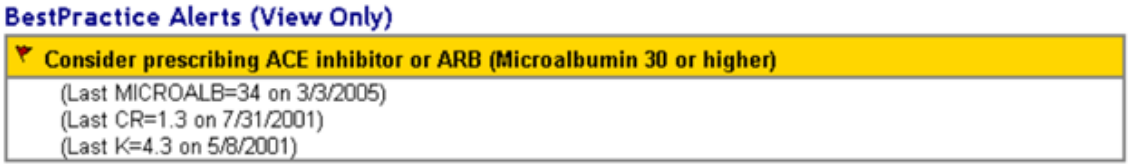


Figure 1 – Electronic health record screen shot of initial diabetes best practice advisory

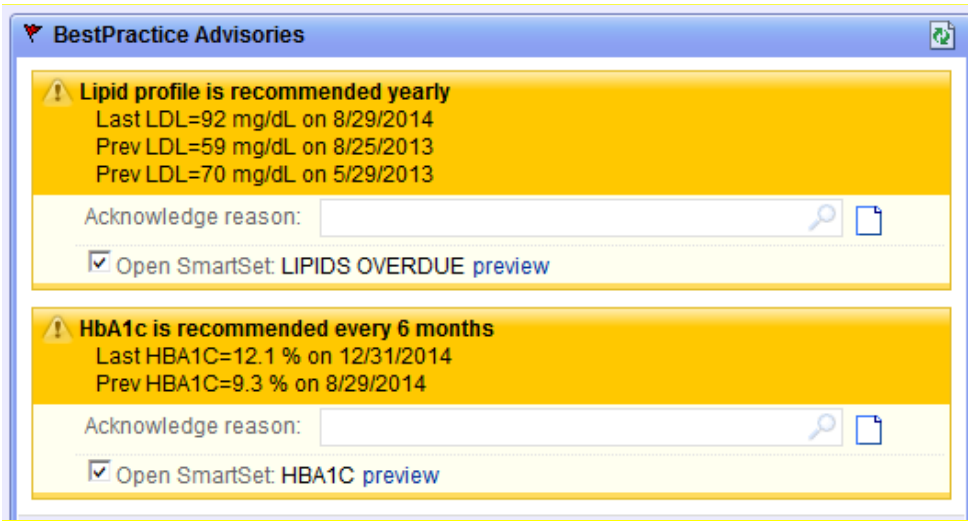
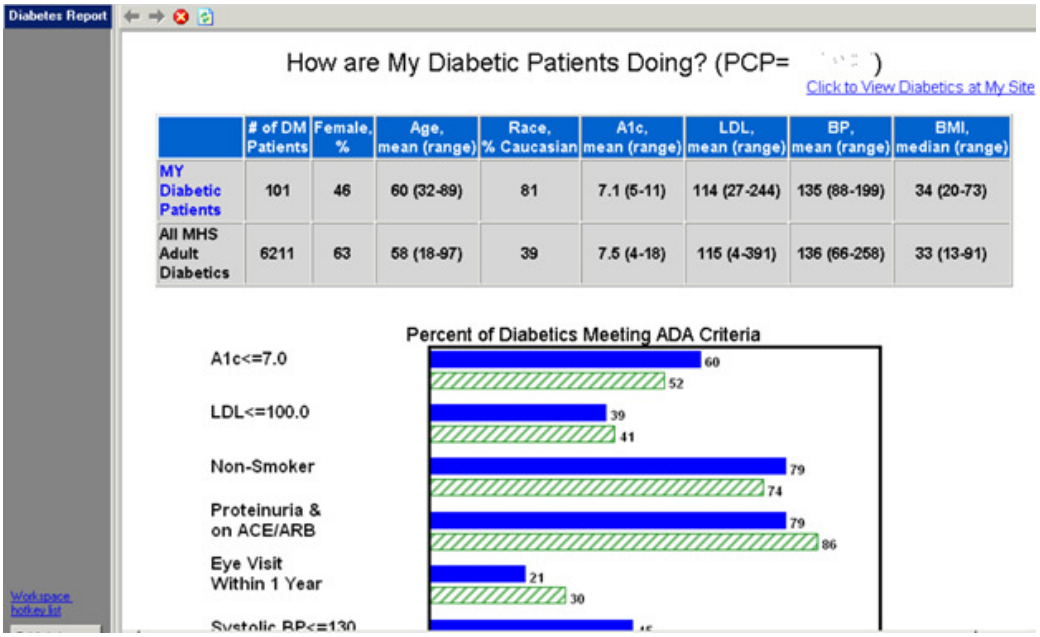


Figure 2 – Electronic health record screen shot of current diabetes best practice advisory



	# of DM Patients	Female, %	Age, mean (range)	Race, % Caucasian	A1c, mean (range)	LDL, mean (range)	BP, mean (range)	BMI, median (range)
MY Diabetic Patients	101	46	60 (32-89)	81	7.1 (5-11)	114 (27-244)	135 (88-199)	34 (20-73)
All MHS Adult Diabetics	6211	63	58 (18-97)	39	7.5 (4-18)	115 (4-391)	136 (66-258)	33 (13-91)

Figure 3 – Electronic health record screen shot of initial diabetes provider level population report

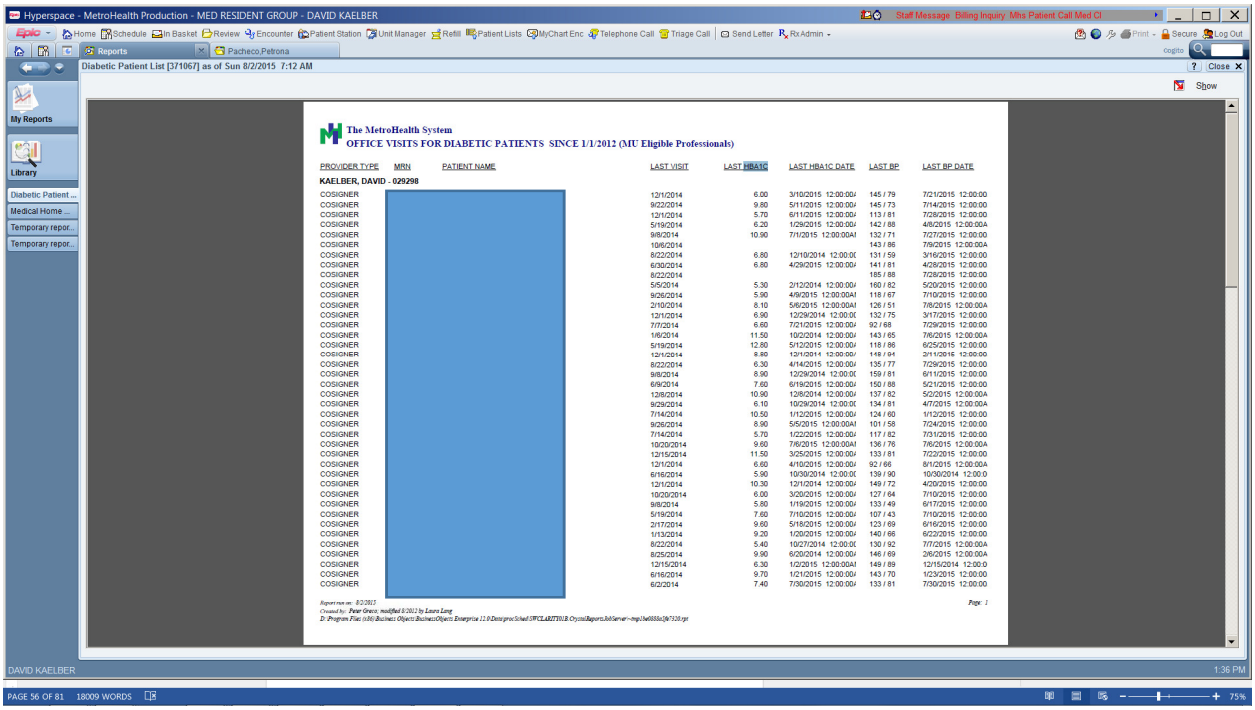


Figure 4 – Electronic health record screen shot of current diabetes provider level population report

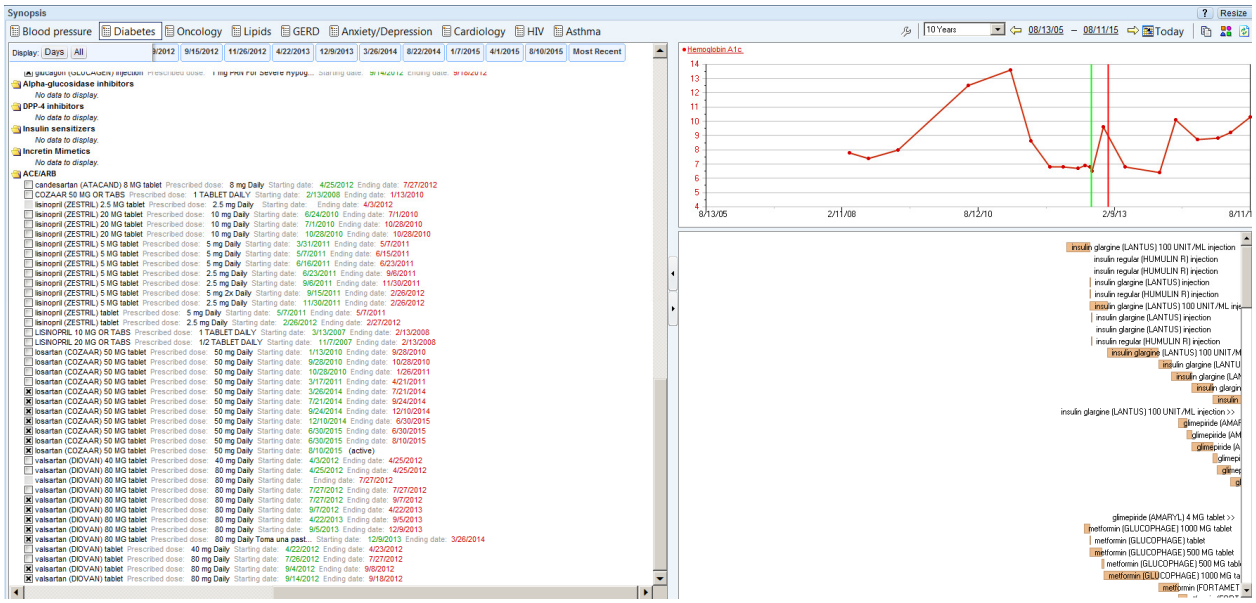


Figure 5 – Electronic health record screen shot of diabetes "Synopsis" report tool that provides summary level diabetes "snapshot" at a patient level

Value Derived

To evaluate the value derived from the MHS's decade-long initiative to improve diabetes care process (MD-centric) and other (patient-centric) outcome measures, composite scores were evaluated over two points in time 2005-2006 and 2007-2014.

During the 2005-2006 period, the composite measure for MD-centric measures (Figure 6) was made up of the percent of patients who achieved all of the following:

- diabetic eye exam performed
- pneumococcal vaccination
- monitoring or treating kidney impairment with ACE inhibitors or ARBs
- control of cholesterol through LDL less than 100mg/dl or patient being on a statin cholesterol lowering medication

During the 2005-2006 period, the composite measure for Other (patient–centric) measures (Figure 6) was made up of the percent of patients who achieved all of the following:

- non-smoking
- body mass index <30
- achieving optimal glycemic control (HbA1c <7%)
- blood pressure <130/80 mmHg

Overall, the EHR tools implemented at the beginning had an ~10% increase in MD-centric measures, which developed and then leveled off over the first 12 months of the study period. These EHR tools had no net effect on Other (patient-centric) measures during the initial two-year study period.

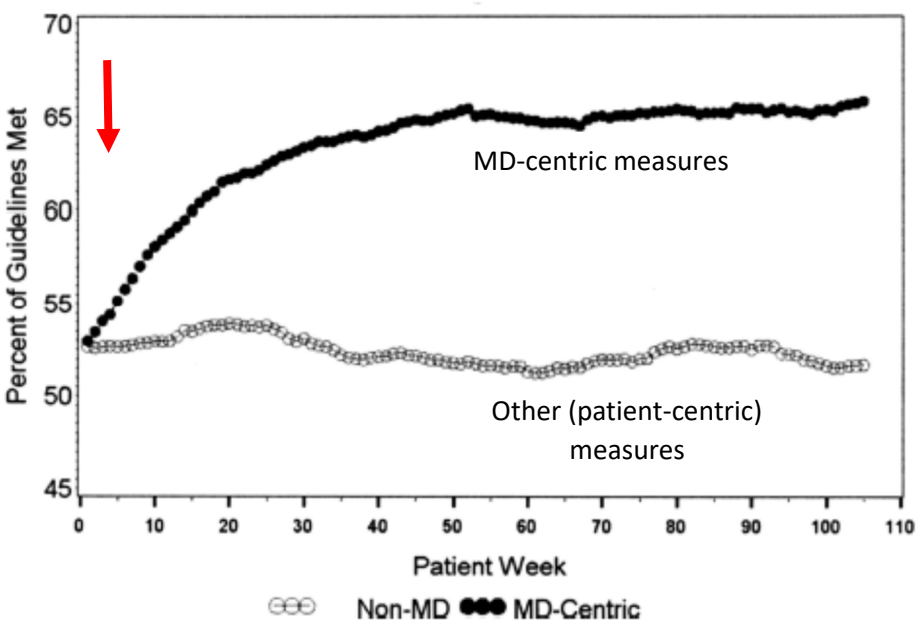


Figure 6 – Diabetes care process (MD-centric) and outcome (Other [patient-centric] measures), 2005-2006. Initial diabetic best practice advisories and provider level diabetes population level report implemented at Patient Week "0" (red arrow)

During the 2007-2014 period, the composite measure for care process measures (Figure 7 summary and Figure 9 detailed) was made up of the percent of patients who achieved all of the following:

- diabetic eye exam performed (EYEEX)
- pneumococcal vaccination (PNEUMO)
- monitoring or treating kidney impairment with ACE inhibitors or ARBs medication (NEPHRO)
- hemoglobin A1c performed (A1CDONE)

During the 2007-2014 period, the composite measure for outcome measures (Figure 8 summary and Figure 10 detailed)) was made up of the percent of patients who achieved at least 4 of the following:

- non-smoking (NONSMOKING)
- body mass index <30 (BMILT30)
- achieving optimal glycemic control (HbA1c <8%) (A1CLT8)
- blood pressure <140/90 mmHg(BPLT14090)
- LDL < 100 or on statin (LDLLT100STAT)

Overall, the EHR tools implemented from 2007-2014 have been associated with a gradual, generally steady increase over 7 year study period. Composite care measures increased about 20% overall from 40.1% in 2007 to 48.5% in 2014. Composite outcome measures increased almost 30% overall from 31.0% in 2007 to 39.5% in 2014. Composite outcomes measure improvement lagged behind composite care measures typically by several years.

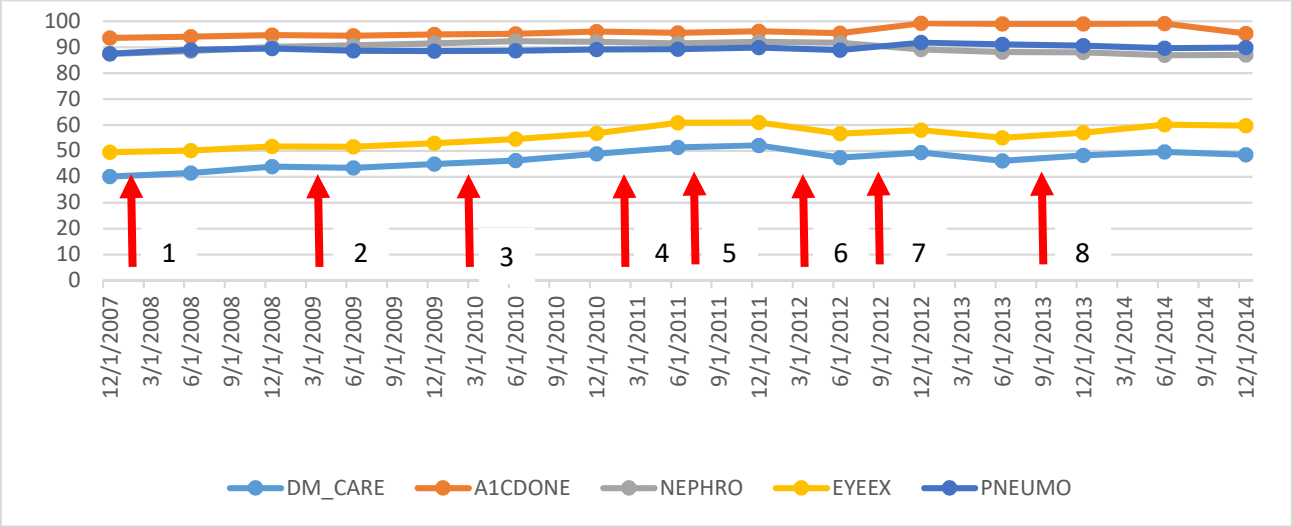


Figure 7 – Summary diabetes care measures 2007-2014. Red arrows indicate EHR interventions: 1-updated best practice advisories, 2 – comparative reports (initial), 3 – diabetic patient care plans (letters), 4 – discrete documentation for eye and foot exams, 5 – comparative reports with financial incentive, 6 – updated diabetic patient care plans (goals, barriers and interventions functionality), 7 – Synopsys reports, 8 – updated provider level diabetic patient lists. DM_CARE is overall composite diabetes care measure. A1CDONE is hemoglobin A1C performed. NEPHRO is monitoring or treating kidney impairment with appropriate medications (angiotensin converting enzyme [ACE] inhibitors or angiotensin receptor blockers [ARBs]). EYEEX is diabetic eye exam performed. PNEUMO is pneumococcal vaccination given.

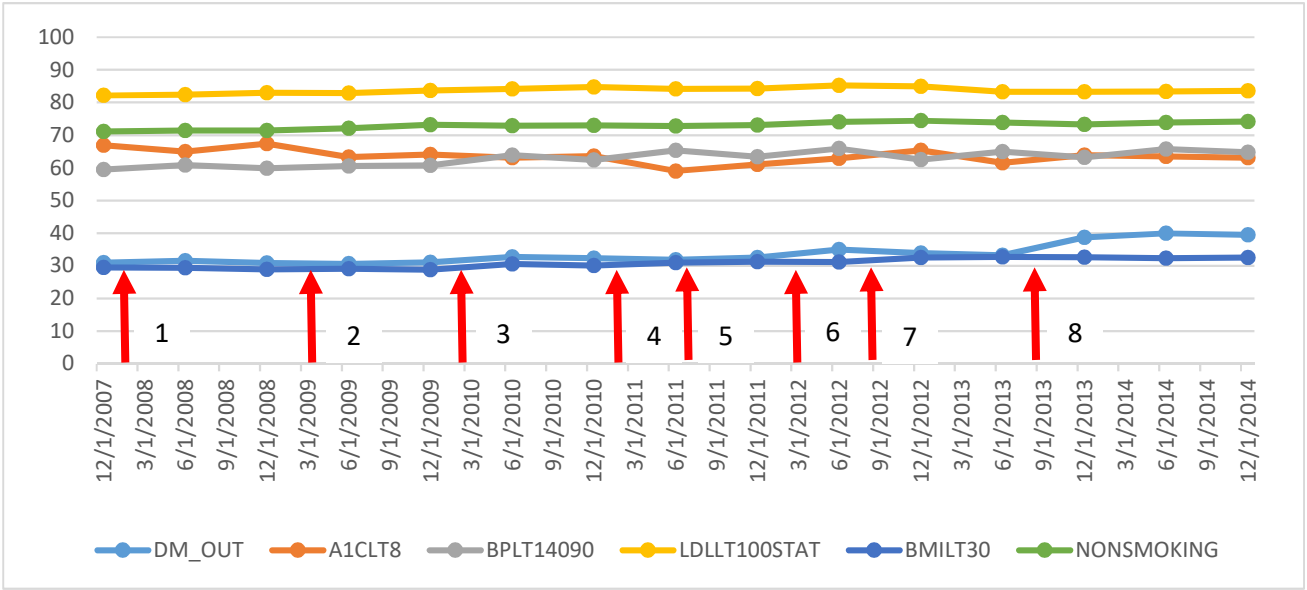


Figure 8 – Summary diabetes outcome measures 2007-2014. Red arrows indicate EHR interventions: 1-updated best practice advisories, 2 – comparative reports (initial), 3 – diabetic patient care plans (letters), 4 – discrete documentation for eye and foot exams, 5 – comparative reports with financial incentive, 6 – updated diabetic patient care plans (goals, barriers and interventions functionality), 7 – Synopsys reports, 8 – updated provider level diabetic patient lists. DM_OUT is overall composite diabetes outcomes measure. A1CLT8 is hemoglobin A1C less than 8. BPLT14090 is blood pressure less than 140/90. LDLLT100STAT is low density lipoprotein less than 100 or patient has been prescribed a statin medication. BMILT30 is body mass index less than 30. NONSMOKING is patient indicates that they are not a current smoker.

Figure 9 – Detailed diabetes care measures for each diabetes care measure shown in Figure 7. Red arrows indicate EHR interventions: 1-updated best practice advisories, 2 – comparative reports (initial), 3 – diabetic patient care plans (letters), 4 – discrete documentation for eye and foot exams, 5 – comparative reports with financial incentive, 6 – updated diabetic patient care plans (goals, barriers and interventions functionality), 7 – Synopsys reports, 8 – updated provider level diabetic patient lists. DM_CARE is overall composite diabetes care measure. A1CDONE is hemoglobin A1C performed. NEPHRO is monitoring or treating kidney impairment with appropriate medications (angiotensin converting enzyme [ACE] inhibitors or angiotensin receptor blockers [ARBs]). EYEEX is diabetic eye exam performed. PNEUMO is pneumococcal vaccination given.

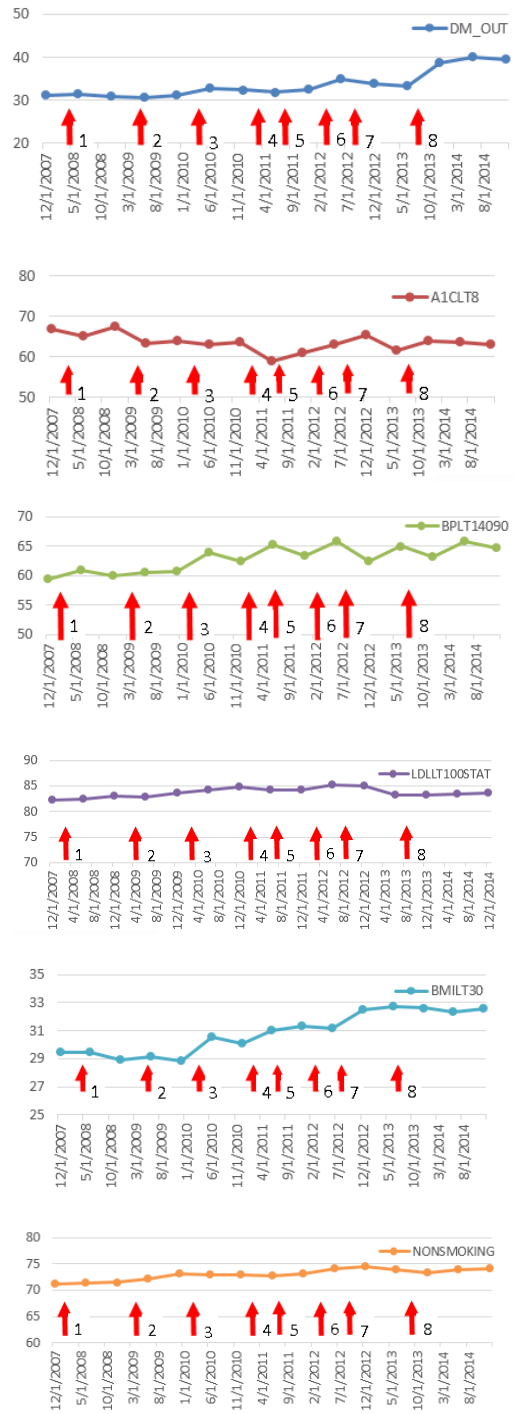


Figure 10 – Detailed diabetes outcome measures for each diabetes outcomes measure shown in Figure 8. Red arrows indicate EHR interventions: 1-updated best practice advisories, 2 – comparative reports (initial), 3 – diabetic patient care plans (letters), 4 – discrete documentation for eye and foot exams, 5 – comparative reports with financial incentive, 6 – updated diabetic patient care plans (goals, barriers and interventions functionality), 7 – Synopsys reports, 8 – updated provider level diabetic patient lists. DM_OUT is overall composite diabetes outcomes measure. A1CLT8 is hemoglobin A1C less than 8. BPLT14090 is blood pressure less than 140/90. LDLLT100STAT is low density lipoprotein less than 100 or patient has been prescribed a statin medication. BMILT30 is body mass index less than 30. NONSMOKING is patient indicates that they are not a current smoker.

Lessons Learned

The primary lesson learned from this example is that through a longitudinal (currently ~10 years), comprehensive, EHR enabled and catalyzed program, significant progress can be made in the quality of care and outcomes for patients with chronic diseases, such as diabetes. From the EHR perspective, such programs can utilize standard EHR tools and data so that there are not significant additional software or hardware costs. The primary costs of developing such programs are people. The teams needed to successfully implement such programs include technical, clinical, analytics and operational representatives. "One tool" will not be sufficient, but rather a suite of tools acting in concert is the most effective approach. When applicable, clinical decision support tools should follow best standards.[1,2] For example, when order sets should be used, alerts should make use of the appropriate order set(s) as obvious and efficient as possible. Additionally, the EHR data and tools are necessary, but not sufficient in themselves for a successful program. Their success is dependent upon having them "wrapped" within programs that educate providers as to overall goals and how the technology tools work, and ideally tie achievement to provider incentives (for example reporting to show how the provider compares to other providers and/or a financial quality incentive). Finally, comprehensive programs such as the adult diabetes one described here have a larger impact on short-term process measure then long-term outcomes measures, although there is an effect on both.

The example and its equivalent application in other healthcare systems, showing the reproducibility of EHR catalyzed initiatives to improve diabetes are in other healthcare systems in Northeast Ohio, has been more fully described and documented in our New England Journal of Medicine article – *Electronic Health Record and Quality of Diabetes Care*.[3] This article shows that EHRs can be used to improve care and outcomes diabetes measure across multiple healthcare systems. This article also describes that systems with EHRs provide higher quality patient care and are able to improve the quality of the care they provide more quickly than health systems with paper based records (Figure 11).

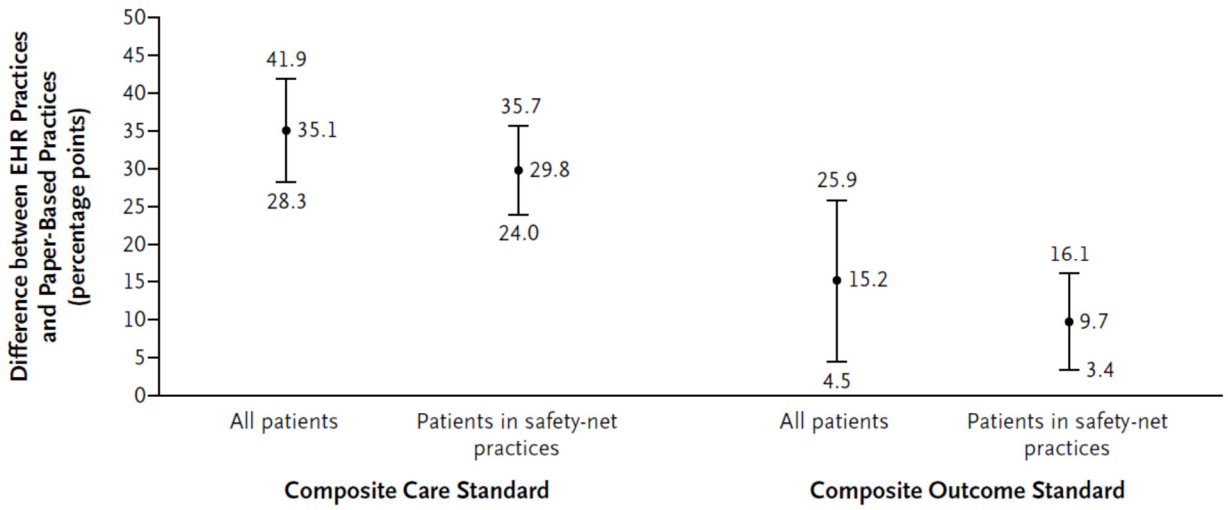


Figure 11 – Composite diabetes score improvements comparing EHR and paper-based practices

Financial Considerations

All of the diabetic EHR-catalyzed initiatives described here used data, tools, and/or functionality already existing in our EHR. Over the ten years of this continuing and evolving effort, a many hundreds of hours of staff time have been spent on the EHR tools designed, build, tested, implemented and continually refined.

In terms of cost savings for this diabetic population, others have estimated that improved diabetes control, as measured by the type of diabetes outcomes measures reported here, saves on the order of 7-10% of healthcare expenses for diabetic patients (~$75-$100 per patient per month or $900-$1200 per patient per year).[4] This cost savings is a combination of decreased ambulatory and inpatient costs because of improved care leading to decreased long-term complications of diabetes. Among the 10,442 patients in this population, 8.44% (881) had improved outcomes. This represents an annual savings on the order of $900,000 in avoided healthcare costs or $3.5 million in avoided healthcare costs over the last decade. Embedded in this cost savings is the estimated at least 17 lower extremity amputations that we avoided because of improved diabetes care among this population, as well as hundreds of hospitalizations.

The estimated initial and on-gong EHR technology and implementation cost of the diabetes technology-enabled interventions was relatively low and decreased over time as "custom" interventions were replaced with interventions using standard EHR functionality and we choose to only implemented standard EHR functionality tools as the standard EHR functionality and tools significantly improved over the decade of this initiative. No additional hardware, software, licensing, or consulting costs were inured initially or on an ongoing basis. The only costs were associated were healthcare researchers, physician informaticists and information services analysts designing, building, testing and maintaining the interventions over time, with some training for providers to understand the details and evidence behind the overall effort and individual initiatives. These costs, per intervention, were estimated to be on the order of about $10,000 on average for the initial build (combination of 20-60 hours of analyst time at

about $50 per hour with benefits and ~50-75 hours of physician time at about $125 per hour with benefits) and about $1,000 on average for annual ongoing maintenance (combination of 0-10 hours of analyst time at about $50 per hour with benefits and about 0-8 hours of physician time at about $125 per hour with benefits). Therefore, costs were approximately $20,000 for the initial build and about $2,000 per year for ongoing maintenance.

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Menu Case Study: *Acinetobacter*/MDROs

Executive Summary

Acinetobacter is a rare, virulent and typically multi-drug resistant organism that can cause significant morbidity and mortality. In the summer/early fall of 2010, the MetroHealth System (MHS) experienced an outbreak of *Acinetobacter* in our hospital. As part of the multi-disciplinary rapid and ongoing response to this outbreak, four different EHR tools were developed and implemented for clinicians. A set of three additional EHR tools were developed and implemented for infection control staff. These seven EHR tools, in combination with other non-EHR interventions, stemmed the *Acinetobacter* outbreak and have led to a steady, now over 30% reduction in overall *Acinetobacter* cases throughout the MHS, eliminating over 200 infections that otherwise would have been expected to occur, saving several million dollars in healthcare costs and probably preventing several deaths. Since implementation five years ago, the MHS has never had a month with as high a number of new *Acinetobacter* cases as it did the month before these tools were implemented.

Local Problem

In the summary/early fall of 2010, the MHS infection control staff identified a case of *Acinetobacter* in a patient in the MHS burn unit who expired. Associated with this was a two-fold increase in hospitalized patients with new *Acinetobacter* infections. Because of the virulence of this organism, the rapid increase in its prevalence and its presence in a patient that died, a healthcare system-wide, multi-disciplinary task force chaired by the Chief Medical Officer and Chair of Infection Control was assembled. The task force included the Chief Information Officer and the Chief Medical Informatics Officer. The goal of the task force was to develop any and all tools, processes and approaches that would stem the tide of the increase in new *Acinetobacter* cases, allow for efficient and effective care of patients with *Acinetobacter*, decrease the overall baseline number of *Acinetobacter* cases and hopefully not allow new *Acinetobacter* cases to reach levels they had in the past.

Design and Implementation

From the overall MHS *Acinetobacter* task force, an Information Services sub-task force was developed that included information services and informatics staff. The goal of this group was to design, build, test and implement EHR based tools and processes in support of the overall *Acinetobacter* task force goals. The sub-task force focused on tools for clinicians that would help to more easily and effectively identify patients with *Acinetobacter*, allow for better handoffs between staff caring for patients with *Acinetobacter* and allow staff to easily screen patients for possible *Acinetobacter* infections. The sub-task force also developed a suite of tools for infection control staff to more efficiently and more completely identify and track patients with *Acinetobacter*.

The final set of EHR tools implemented by the sub-task force included:

- Tools for Clinicians (all MDROs)
  - MDRO Header and Patient Name
  - MDRO Best Practice Alert
  - MDRO Handoff Communications
  - MDRO Screening Culture
- Tools for Infection Control Staff (*Acinetobacter*)
  - Reporting Workbench Reports
  - Daily emails
  - Paging for positive cultures/admissions

How Health IT Was Utilized

Tools for Clinical Staff

Tools for clinical staff were developed to more easily identify patients with any multi-drug resistant organism (MDRO), which included *Acinetobacter*, and isolation procedures that were in place for those patients. Patients with an MDRO where identified with a special "mdro!" status in their patient name field (Figure 1). Any isolation status that the patient may have because of their MDRO was also clearly added to the patient's EHR header (Figure 1). The special name MDRO nomenclature also included a hyperlink that showed all relevant cultures related to a patient's MDRO status (Figure 2). The isolation status also included a hyperlink to clearly describe the details of all isolations status for improved compliance with the isolation status (Figure 3). Best practice clinical decision alerts were also developed for patients with MDROs if they did not appear to have appropriate isolation orders (Figure 4).

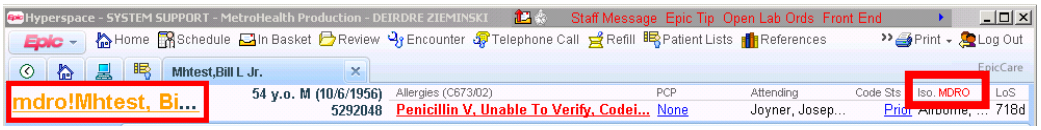


Figure 1 – Electronic health record screen shot showing special MDRO hyperlinked patient name (upper left-hand red box) and patients isolation status (upper right-hand red box)

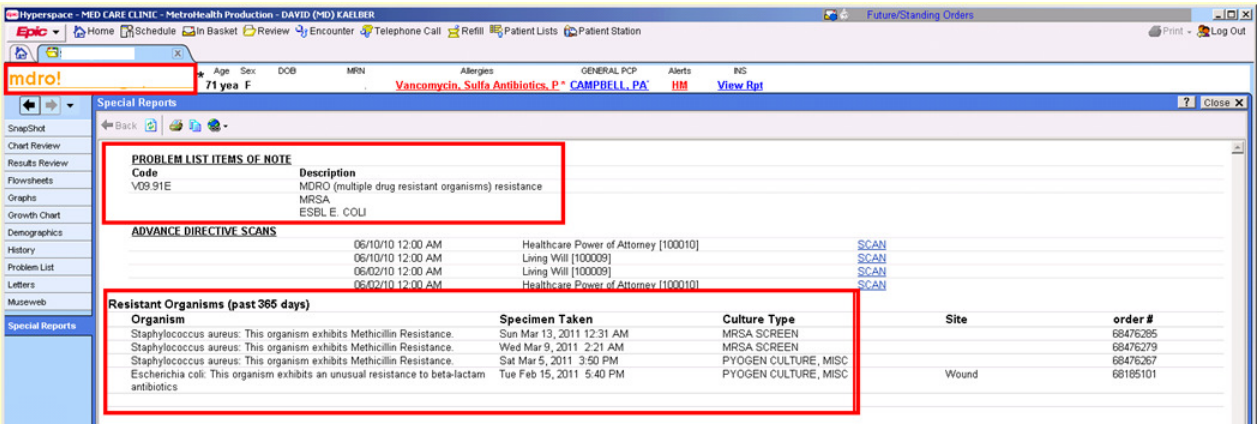


Figure 2 – Electronic health record screen shot showing hyperlink MDRO culture details (red boxes)

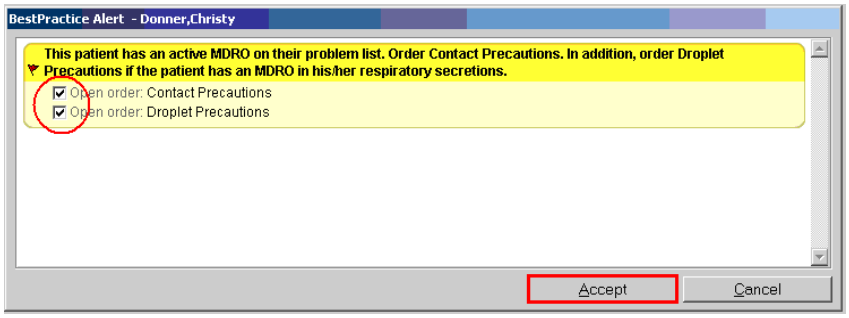


Figure 3 – Electronic health record screen shot showing MDRO isolation order clinical decision support

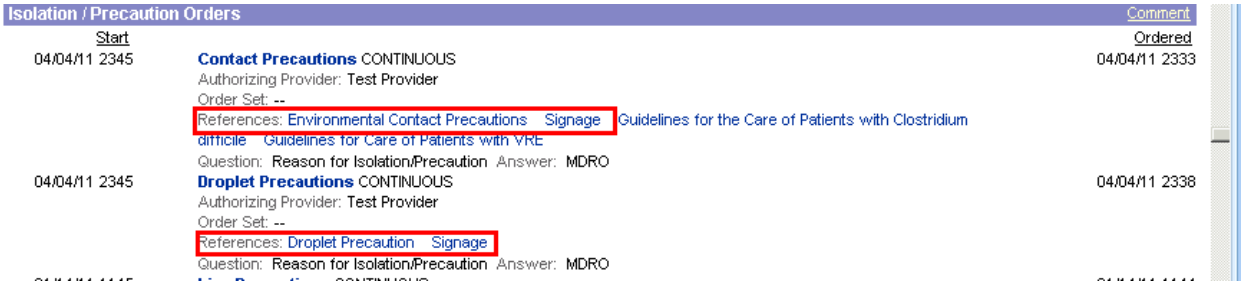


Figure 4 – Electronic health record screen shot showing isolation hyperlink details

To help ensure that a patient's MDRO status and necessary isolation precautions were known and maintained at transitions of care throughout the healthcare system, tools were developed so that staff could easily identify and pro-actively prepare for patients with MDROs. The transition of care nursing handoff SBAR report was modified to include a section for isolation precautions (Figure 5). Schedules were modified to include a column to identify a patient's MDRO status (Figure 6).

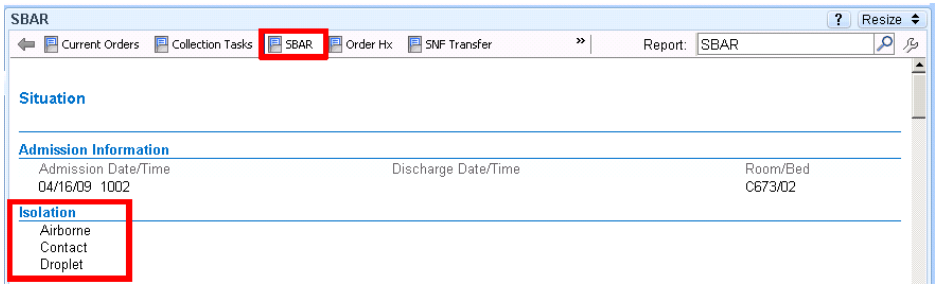


Figure 5 – Electronic health record screen shot showing patient isolation order in SBAR report

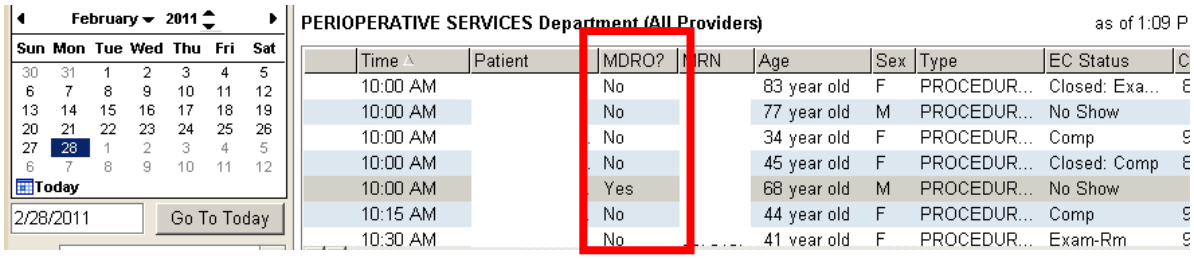


Figure 6 – Electronic health record screen shot showing MDRO schedule column

Another important aspect of the generalized MDRO EHR interventions developed with the support of the *Acinetobacter* task force, was the ability to screen patients (and objects) to check their MDROs. This required development of a special order in the EHR so that the specimens could be specially processed and billed (Figure 7).

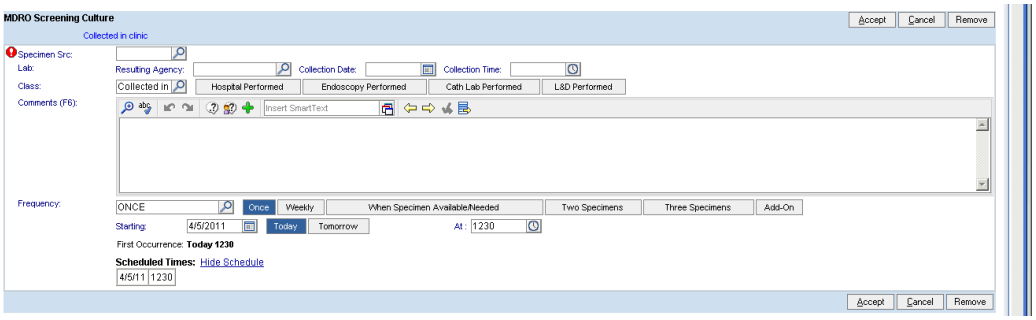


Figure 7 – Electronic health record screen shot showing specially developed MDRO screening order

Tools for infection Control Staff

Tools were developed for infection control staff to promote better real time notification of newly diagnosed and newly presenting patients with MDROs. This notification allowed infection control staff to intervene in real time to control the infection in the patient and to reduce the potential spread of infection to other patients as quickly as possible. The primary tool developed for this was integration between the laboratory information systems, the EHR, the admission, discharge, and transfer system and the paging system. Tools were implemented so that any time a patient with *Acinetobacter* presented to our emergency department or inpatient area the ADT system sent out a page to the infection control staff on call to immediately alert staff in the area to ensure that appropriate infection control measures were being taken.

Additionally, daily reports were developed (that could be re-run and updated manually at any time) (Figure 8). These reports were available in the EHR and also automatically emailed to interested parties daily.

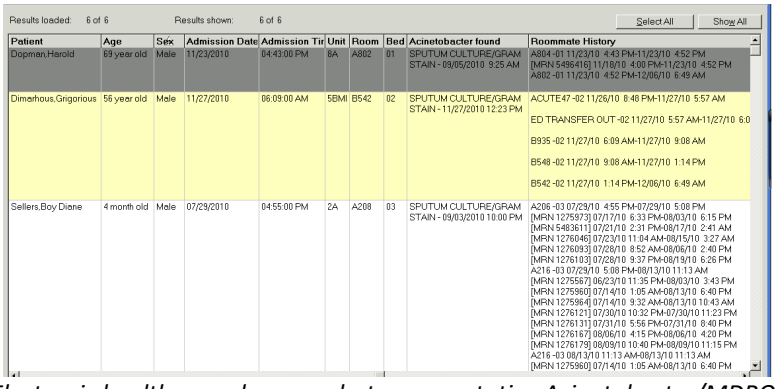


Figure 8 – Electronic health record screen shot representative Acinetobacter/MDRO population report

Value Derived

The *Acinetobacter* task force continued from the fall of 2010 through the fall of 2011 at which time it was recognized that the increase in *Acinetobacter* had been addressed and that systems were in place to continue addressing *Acinetobacter* (and other MDROs). The task force was disbanded with continued monitoring for new *Acinetobacter*. Figure 9 shows the incidence of new *Acinetobacter* infections per month "pre-task force" (1/09-7/10) and "post-task force" (8/10-5/15).

Prior to the Task Force creation, the average rate of new *Acinetobacter* infections was an average of 12 per month over the preceding 18 months, with several spikes of over 20 per month. The creation of the Task Force quickly (within 1 month) eliminated the upward trend in new *Acinetobacter* infections. Over the subsequent almost 4 years, even after the Task Force stopped meeting there has been a generally steady decrease in new *Acinetobacter* infections such that the average number of new *Acinetobacter* infection over the last 46 months has been 9 per month and only one month where there has ever been over 15 new cases. Given the significant increase in prevalence in the first half of 2010, these interventions probably stopped upwards of 50 new *Acinetobacter* infections in 2010. Establishing a new baseline over time (2011 to present) stopped another 162 new *Acinetobacter* infections from occurring. This EHR enabled improvements effort was recognized by the Association of Medical Directors of Information Service in 2011. Figure 10 shows the rate of attributed hospital acquired MDRO *Acinetobacter* infections (the most serious *Acinetobacter* infections we were trying to reduce) from 2009 to 2014. Figure 12 shows the hand hygiene compliance rate from12/2010 to 12/2014 which was a non-IT enabled strategy also employed to stem Acinetobacter. MDRO infections.

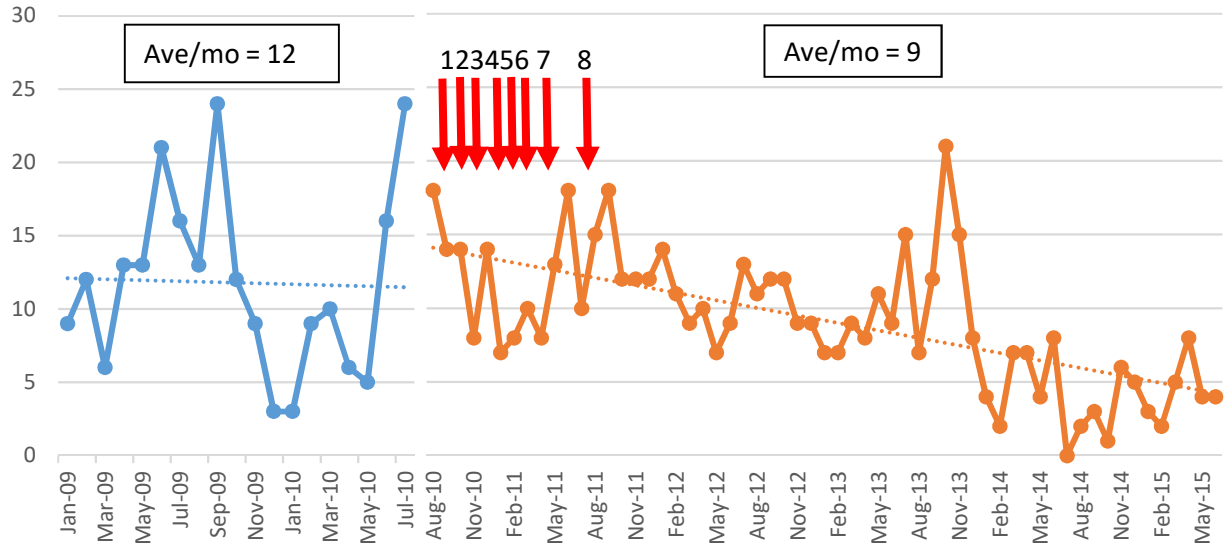
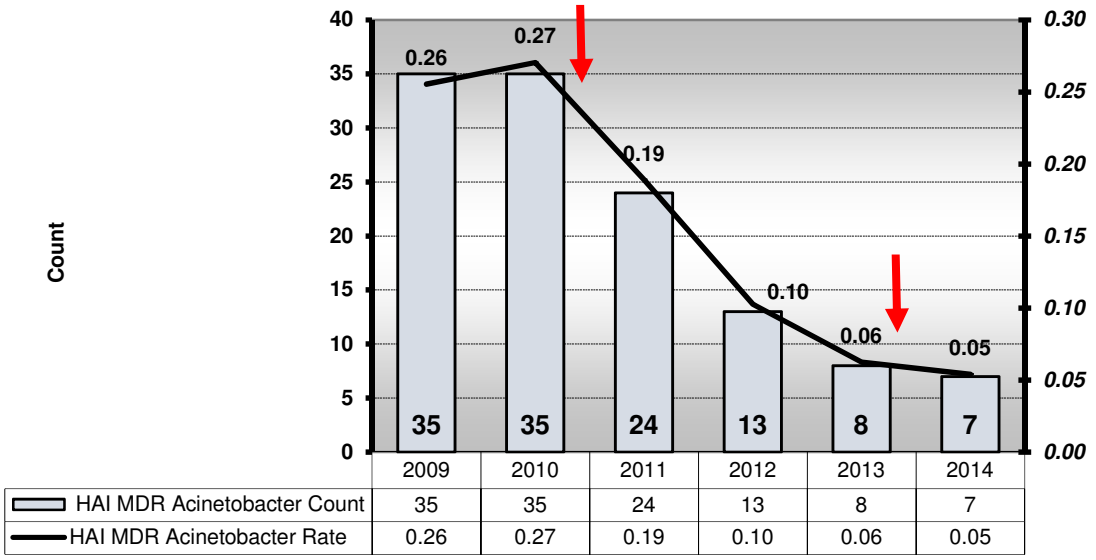


Figure 9 – Incidence of Acinetobacter infections "pre-task force" (blue line) and "post-task force" (orange line). Red arrows indicate when various EHR tools were added: 1- hyperlinked patient header, 2 – hyperlinked isolation status, 3 – MDRO SBAR report, 4 – MDRO schedule column, 5 – MDRO best practice alert, 6 – MDRO patient lists with daily emails, 7 – MDRO patient pages from ADT system to infection control staff, 8 – MRDO surveillance culture order



	2009	2010	2011	2012	2013	2014
HAI MDR Acinetobacter Count	35	35	24	13	8	7
HAI MDR Acinetobacter Rate	0.26	0.27	0.19	0.10	0.06	0.05

Figure 10 – Annual trend in MDRO Acinetobacter Count and Rate 2009-2014. Red arrows indicate significant intervention periods. 2010-2011 IT interventions include: 1 – hyperlinked patient header, 2 – hyperlinked isolation status, 3 – MDRO SBAR report, 4 – MDRO schedule column, 5 – MDRO best practice alert, 6 – MDRO patient lists with daily emails, 7 – MDRO patient pages from ADT system to infection control staff, 8 – MRDO surveillance culture order. 2013-2014 IT interventions – automated environmental service notifications

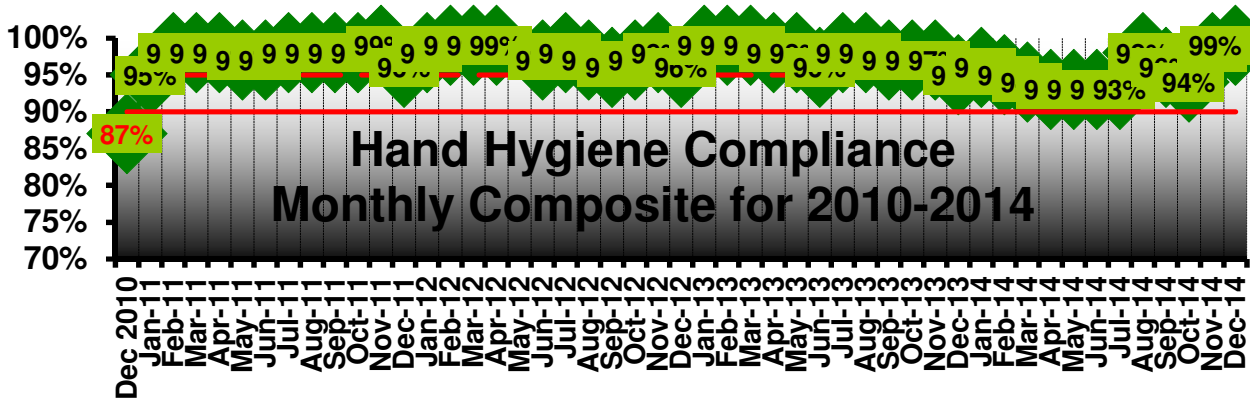


Figure 11 – Hand hygiene rates from 12/2010 through 12/2014. Improved hygiene also contributed to improvements although this was a non-IT intervention. Hand hygiene compliance was measured through manual observations of specialized hand hygiene compliance personnel.

Lessons Learned

The MHS's *Acinetobacter* outbreak had nothing to do with the EHR/HIT, but it demonstrates the cultural shift that had occurred within the MHS since the EHR was first installed starting in 1999. When any important clinical or operational issue arises in the MHS, the EHR specifically and HIT generally are seen as tools to bring to bear as part of a solution(s). Leaders and representatives from information services and informatics are seen a critical members to address these issues even if EHR/HIT is not a direct cause and it may initially seem like the EHR/HIT may not be able to contribute to a solution(s).

As with other complex change management and quality improvement efforts related to the EHR, several specific key lessons learned include:

1. Inter-disciplinary team is critical (in this case – infection control, clinical, quality improvement, information services and clinical informatics)
2. Typically, for complex issues no single intervention will provide a "magic bullet;" rather a series of interventions (technical and non-technical) can provide significant and long-term impact, but will still not provide perfection for any process that still involves people
3. Developing initial and ongoing outcomes (in this case monthly new *Acinetobacter* infection) is needed so that initial and ongoing success can be evaluated
4. When issues arise, evaluate if there are larger opportunities associated with the issue (here the initial issue was *Acinetobacter*, but in designing and implementing solutions we took into account all MDROs)

Financial Considerations

All of the tools implemented as part of this effort relied on existing functionality of the EHR/HIT infrastructure already in place in the MHS. The cost to implement these features was only the MHS staff time need to design, build, test and implement, estimated at several hundred hours.

With the significant rise in *Acinetobacter* infections, these interventions (along with non-technical interventions not described, like increased focus on hand hygiene and changes in room cleaning methods) are estimated to have reduced new *Acinetobacter* infections by 52 in 2010, and from 2011 through mid-2015 by another 162 infections. Using a representative cost per new *Acinetobacter* infection of at least $25,000 (estimated typical cost hospital acquired infections),[1,2] this initiative has saved at least $4.3 million dollars to date in healthcare expenses and is anticipated to save at least $1 million annually on an ongoing basis.

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Menu Case Study: Infectious Diseases (HIV and HCV) Screening

Executive Summary

Guidelines for screening for high risk infectious diseases, specifically human immunodeficiency virus (HIV) and hepatitis C virus (HCV), are of particular importance in relatively high-risk patient populations like those seen within the MetroHealth System (MHS). The recommendations have evolved: In January 2005, the US Preventive Services Task Force (USPSTF) recommended once-lifetime screening for HIV among "high risk" adolescents and adults ages 15-64 (where the CDC defined a population as "high risk" based on its baseline prevalence for HIV within all patients of the healthcare system). As a whole, the MHS patient population met the definition. In June 2013, the USPSTF recommended once-lifetime screening for HCV among adults born 1945-1965.

The MHS implemented electronic health record (EHR) health maintenance reminders for HIV and HCV in July 2010 and July 2013 respectively. For HIV, these reminders caused an increase in screening of more than 225% and an increase in disease detection of 11%. For HCV, these reminders caused an increase in screening of over 2500% and an increase in disease detection of 560%.

Although these examples show the effectiveness of EHR health maintenance reminders important insights came from comparing and contrasting the effectiveness of the health maintenance reminders for HIV and HCV. In both cases, point-of-care health maintenance reminders significantly increased screening. However, screening rates among all eligible patients within the healthcare system remained below 50%. This relatively low screening rate argues for adding an active population management approach to the point-of-care health maintenance reminders. Additionally, the yield of the screening (number needed to screen for a positive test) went down for both HIV and HCV as screening became more universal. This points to the idea that prior to the implementation of the health maintenance reminders, providers were screening disproportionally more high-risk patients.

Local Problem

The MHS infectious disease staff were interested in implementing USPSTF recommended universal screening of patients for HIV and HCV. The staff recognized that this screening would need to occur primarily in the primary care clinics within the MHS. They wanted a way to "notify" primary care providers that the screening for HIV and/or HCV needed to be done. In addition, they thought it would be easier for primary care providers if they were provided an easy way to order the recommended screening. The infectious disease staff approached the MHS clinical informatics team for help.

Design and Implementation

Together, the infectious disease staff and clinical informatics team formed a "mini-task force" to implement the EHR health maintenance reminders for HIV and then HCV screening. The HIV

and then HCV health maintenance reminders were designed, built, tested, implemented and monitored by a combination of infectious disease and clinical informatics staff.

Primary care providers and other MetroHealth staff learned about the new reminders via EHR staff messages and by seeing the reminders for their patients. Any patients "due" for a health maintenance reminder has an indicator in the patient's EHR header ("HM Due" shows up in red when a patient is due (Figure 1) and extinguishes if all health maintenance reminders are up to date). Because other health maintenance rules were already active in the MHS EHR, primary care providers were already accustomed to looking at the patient header for the indicator flag. In addition, for the HIV health maintenance reminder, infectious disease staff provided "in-services" for clinic staff over a several month period.

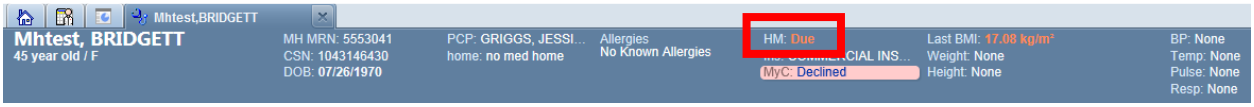


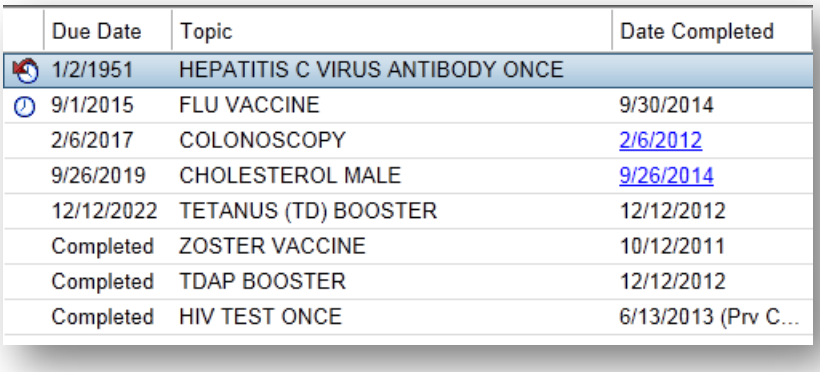
Figure 1 – Electronic health record screen shot showing patient with "due" HM (health maintenance flag)

Despite the USPSTF grade "A" recommendation (The USPSTF recommends the service and there is high certainty that the net benefit is substantial) for HIV screening and grade "B" recommendation (The USPSTF recommends the service and there is high certainty that the net benefit is moderate or there is moderate certainty that the net benefit is moderate to substantial) for the HCV screening, there was local disagreement among providers who were called upon to implement the screening. The dissenting provider argued that, while the CDC definition of "high risk" might apply to the entire MHS population (based on HIV prevalence in our healthcare system population), they felt that their own patients were not at high risk. Some publicly stated that they were not going to follow the recommendation (in 2013 the USPSTF revised their HIV screening recommendation again, this time dropping the "high risk" qualifier and therefore indicating that everyone ages 15-64 should have once in a lifetime HIV screening – grade A recommendation).

How Health IT Was Utilized

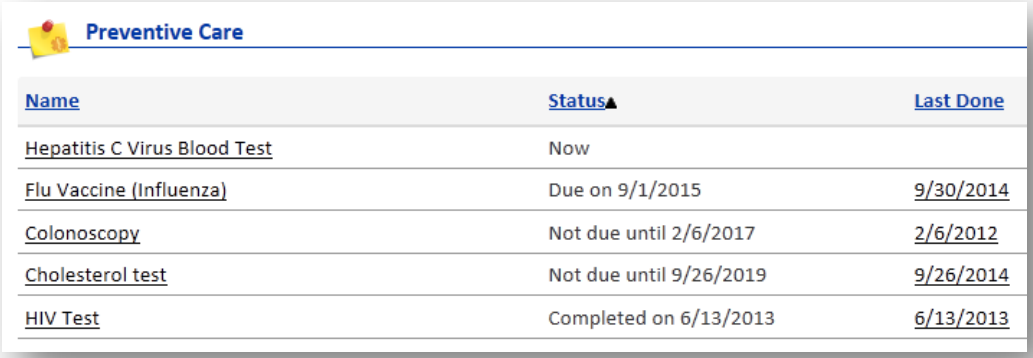
The infectious disease and clinical informatics used standard health maintenance rule/reminder functionality within the Epic EHR to build HIV and then HCV health maintenance reminders. These reminders are shown to providers, if any are due, when they click on the HM: Due link in the patient header. Specific topics due, date due, and most recent date completed (if applicable) are all shown (Figure 2).

In the last several years, as MHS has deployed the Epic personal health record, health maintenance reminders are also shown to patients through the personal health record (Figure 3).



Due Date	Topic	Date Completed
1/2/1951	HEPATITIS C VIRUS ANTIBODY ONCE	
9/1/2015	FLU VACCINE	9/30/2014
2/6/2017	COLONOSCOPY	2/6/2012
9/26/2019	CHOLESTEROL MALE	9/26/2014
12/12/2022	TETANUS (TD) BOOSTER	12/12/2012
Completed	ZOSTER VACCINE	10/12/2011
Completed	TDAP BOOSTER	12/12/2012
Completed	HIV TEST ONCE	6/13/2013 (Prv C...

Figure 2 – Electronic health record screen shot showing details of health maintenance topics due, to providers



Preventive Care

Name	Status	Last Done
Hepatitis C Virus Blood Test	Now	
Flu Vaccine (Influenza)	Due on 9/1/2015	9/30/2014
Colonoscopy	Not due until 2/6/2017	2/6/2012
Cholesterol test	Not due until 9/26/2019	9/26/2014
HIV Test	Completed on 6/13/2013	6/13/2013

Figure 3 – Personal health record screen shot showing details of health maintenance topics due, to patients

Value Derived

The value of the health maintenance reminders (HIV and then HCV) can be measured in terms of increased screening (process measure) and increase in disease detection (outcome measure). For the HIV health maintenance reminders, screening per month increasing by over 225%, while the increase in positive tests was only 11%. The "effectiveness" of the testing decreased by more than 50% (i.e. more than double the number of people needed to be screened for each positive test) (Figure 4 and Table 1).

The EHR HIV health maintenance reminder has led to an additional average 2-3 HIV cases being diagnosed per year since implementation. Early diagnosis can save up to $75,000 in healthcare costs for the person being diagnosed.[1] Also, it can decrease the chance that the HIV+ person will infect others with HIV, at an estimated lifetime costs of almost $400,000 per HIV case.[2] Therefore, the EHR HIV health maintenance reminder saves at least an estimated $150,000 per year in lifetime healthcare costs through at least two cases being diagnosed earlier.

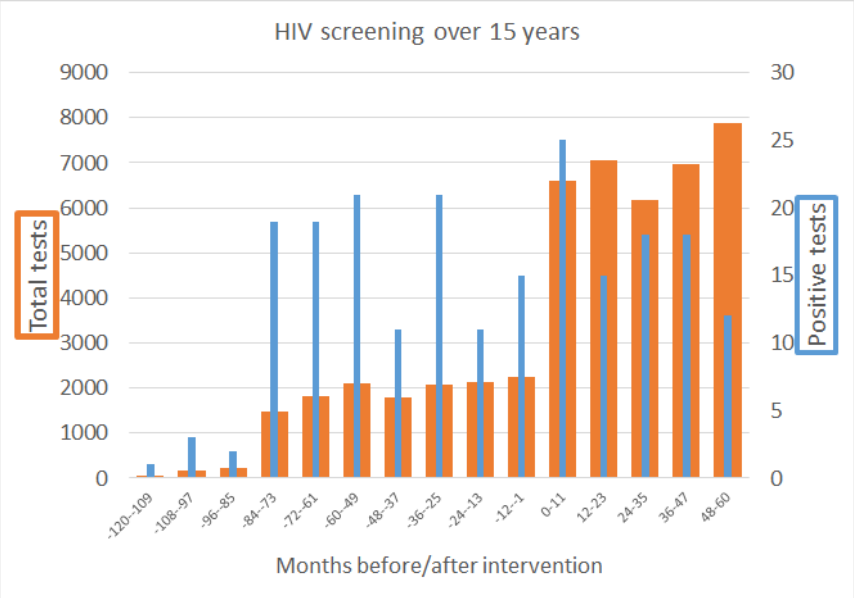


Figure 4 – Trends in HIV screening total and positive test (2000-2015) (Month 0 is 7/2010 when EHR HIV health maintenance reminder implemented)

HIV	Pre-Intervention	Post-Intervention
Time Period	7/2005-6/2010	7/2010-6/2015
Total Tests	10,350	34,628
Tests per month	172.5	577.1
Total positive tests	79	88
Positive tests per month	1.3	1.5
Proportion of tests positive for HIV	0.8	0.3

Table 1 – Pre-Post implementation evaluation of EHR HIV health maintenance reminder

For the HCV health maintenance reminders, screening per month increasing by over 2500%, and positive tests increased by 560%. The proportion of tests positive for HCV decreased by approximately 60% (Figure 5 and Table 2).

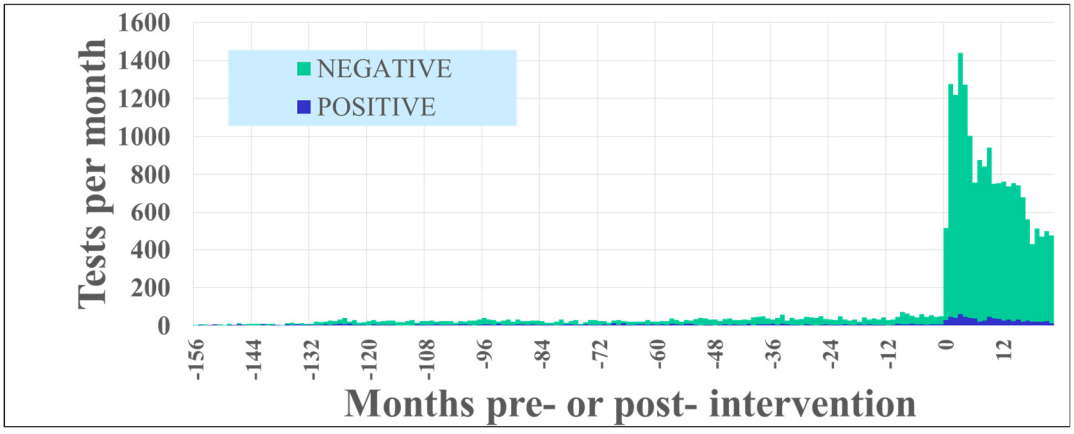


Figure 5 – Trends in HCV screening total and positive test (2000-2015) (Month 0 is 7/2013 when EHR HCV health maintenance reminder implemented)

HCV	Pre-Intervention	Post-Intervention
Time Period	7/2000-6/2013	7/2013-6/2015
Total Tests	5,066	19,833
Tests per month	32.5	826.4
Total positive tests	776	790
Positive tests per month	5.0	32.9
Proportion of tests positive for HCV	15.3%	4.0%

Table 2 – Pre-Post implementation evaluation of EHR HCV health maintenance reminder

The HCV reminders were more effective in increasing screening then the HIV reminders. This is somewhat surprising given that the education surrounding the roll-out of the HIV screening included "in services" by the infectious disease staff. The HCV health maintenance reminders were more effective in increasing screening probably because providers had a stronger "belief" that the HCV recommendations were more applicable to their patients. In addition, the baseline rate of screening for HIV was higher than for HCV prior to implementation of the health maintenance reminders. Finally, the difference in disease detection rates is almost certainly related to the fact that the prevalence of HIV in the MHS population is lower than the prevalence of HCV.

The EHR HCV health maintenance reminder has led to an additional average 335 HCV cases being diagnosed per year since implementation. Early diagnosis, depending on the stage of liver cirrhosis, can save on the order of $10,000 of lifetime expenses.

Lessons Learned

The infectious diseases (HIV and HCV) example demonstrates both the power and limitations of health maintenance reminders to improve clinical care and compliance with guidelines.

Key lessons learned include:

1. Inter-disciplinary team is critical (in this case infectious disease and clinical informatics)
2. Point of care health maintenance reminders improve compliance with recommendations, but still leave many patients without recommended care because:
    a. They do not come to a face-to-face visit
    b. At the face-to-face visit the recommendations are not followed
3. Point of care reminders should probably be coupled with population health strategies outside of the point of care to increase compliance (and the same rules used for the point of care reminders to be leveraged for the population health strategies)
4. Showing patients health maintenance reminders through their personal health records does not significantly improve compliance
5. If providers (the group being shown the clinical decision support) do not believe the science behind the underlying recommendation, compliance with the clinical decision support will suffer

Financial Considerations

All of the tools implemented as part of this effort relied on existing functionality of the EHR infrastructure already in place with in MHS. The cost to implement these feature was only the MHS staff time need to design, build, test, and implement, estimated at a several tens of hours.

Since 2010, based on comparison to historical trends, MHS has diagnosed an additional at least 12 patients with HIV because of the EHR HIV health maintenance alert. These 12 earlier diagnosed cases because of screening, represent almost $1 million (~$180,000/year) in healthcare costs avoided in these patients. These 12 cases also represent potentially 1-2 cases of stopped HIV transmission from these cases at a healthcare cost avoidance of approximately $400,000 per new case avoided. The estimated cost per additional HIV screening test is about $10 per test so that to screen an additional approximately 7,000 patients per year is about $70,000, typically covered by third-party payers.

Since 2013, based on comparison to historical trends, MHS has diagnosed an additional 670 patients with HCV because of the EHR HCV health maintenance alert. These 670 earlier diagnosed cases because of screening, represent approximately $6.7 million ($3.4 million/yr) in healthcare costs avoided in these patients.

The estimated initial and ongoing EHR technology and implementation cost of the EHR HIV and HCV health maintenance reminders were low, as standard health maintenance reminder building blocks already existing in the EHR were used and other health maintenance reminders were already deployed in our healthcare system, which providers were familiar with. Therefore, there were no additional hardware, software, licensing or consulting costs. The only costs were associated with infectious disease physicians, physician informaticists and information services analysts designing, building, testing and maintaining the reminder over time, with some initial training for providers to understand the details and evidence behind the HIV screening recommendations. These costs, per alert, are estimated to be about $10,000 for the initial build (about 50 hours of analyst time at about $50 per hour with benefits and ~60 hours of physician time at about $125 per hour with benefits) and about $1,000 for annual ongoing maintenance (about 5 hours of analyst time at about $50 per hour with benefits and about 6 hours of physician time at about $125 per hour with benefits). Therefore, approximately $20,000 for the initial build and about $2,000 per year for ongoing maintenance.

Together, the HIV and HCV health maintenance reminders have saved over almost $8 million in healthcare expenses and are expected to continue to save $3.5-$4.0 million annually.

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