MetroHealth 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.*

MetroHealth Core Case Study: Return on Investment

Financial Value: Historical Ambulatory EHR ROI

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**

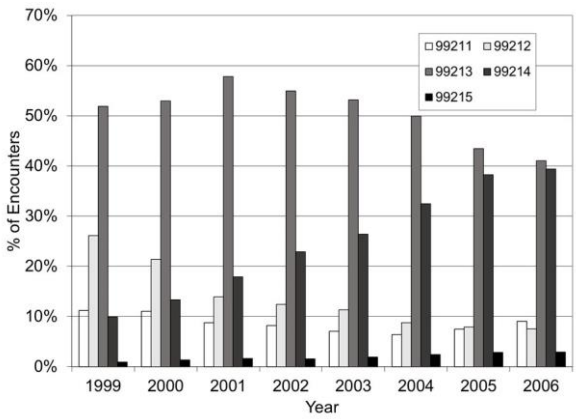

Figure 1 - Common Procedural Terminology Evaluation and Management Coding Mix 1999-2006 Among Most Common Codes

MetroHealth Core Case Study: Return on Investment

Financial Value: Historical Ambulatory EHR ROI

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

MetroHealth Core Case Study: Return on Investment

Financial Value: Historical Ambulatory EHR ROI

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

MetroHealth Core Case Study: Return on Investment

Financial Value: Historical Ambulatory EHR ROI

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.

Financial Value: Historical Ambulatory EHR ROI

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.

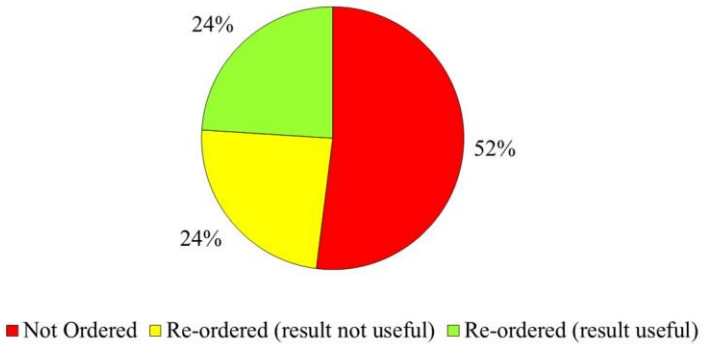

Figure 1 – Result of clinical decision support on duplicative urine culture order

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.

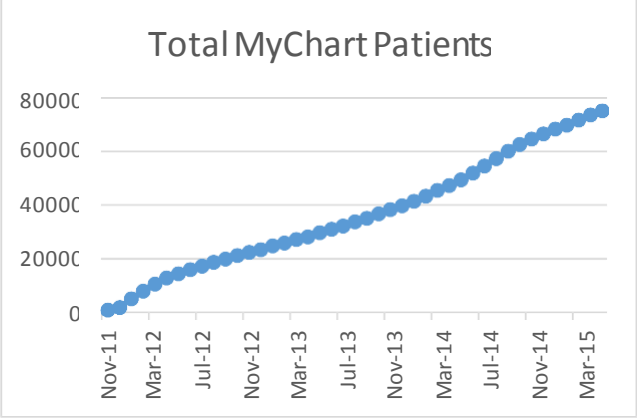

Figure 2 – Total patients enrolled in MyChart over time

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 Bibliography of EHR Related Publications and Abstracts

Publications

1. MJ Mhana, AM Iqbal, and DC Kaelber. *Hypertension at School Age in Extremely Low Birth Weight Infants*. Journal of Neonatal-Perinatal Medicine. 2015. (In press)
2. RD Cebul, TE Love, D Einstadter, AS Petrulis, amd JR Corlett. *MetroHealth Care Plus: Effects Of A Prepared Safety Net On Quality Of Care In A Medicaid Expansion Population.* Health Affairs (Millwood). 2015 Jul 1;34(7):1121-30. doi: 10.1377/hlthaff.2014.1380. PMID:26153306.
3. AG Fiks, RW Grundmeier, J Steffes, WG Adams, DC Kaelber, WD Pace, and RC Wasserman for the Comparative Effectiveness Research through Collaborative Electronic Reporting (CER^2) Consortium. *Comparative Effectiveness Research through Collaborative Electronic Reporting (CER^2): Advancing Child Health Research*. Pediatrics. 2015. Jul;136(1):e215-24. doi: 10.1542/peds.2015-0673. Epub 2015 Jun 22. PMID:26101357.
4. MA Baker, DC Kaelber, DS Bar-Shain, PL Moro, B Zambarano, M Mazza, C Carcia, A Henry, R Platt, and M Klompas. *Advanced Clinical Decision Support for Vaccine Adverse Event Detection and Reporting*. Clinical Infectious Diseases. 2015. Jun 9. pii: civ430. PMID: 26060294.
5. DS Bar-Shain, MM Stager, AP Runkle, JB Leon, and DC Kaelber. *Direct Messaging to Parents/Guardians to Improve Adolescent Immunizations*. Journal of Adolescent Health. 2015 May;56(5 Suppl):S21-6. PMID:25863550.
6. V Patel and DC Kaelber. *Using Aggregated, De-Identified Electronic Health Record Data for Multivariate Pharmacosurveillance: A Case Study of Azathioprine*. Journal of Biomedical Informatics (Special Clinical Research Informatics issue). 2013 Oct 28. pii: S1532-0464(13)00161-5. [Epub ahead of print] PMID:24177317.
7. DC Kaelber, R Waheed, D Einstadter, TE Love, RD Cebul. *Use and Perceived Value of Health Information Exchange – One Public Healthcare System's Experience*. American Journal of Managed Care (Special Health Information Technology issue). Am J Manag Care. 2013; 19(10 Spec No. 10):SP337-343. PMID:24511888.
8. M Clark, M Stager, and DC Kaelber. *The Relationship of Pre-pubertal BMI Status to Post-pubertal BMI Status: An 8-Year Cohort Study*. J Obes Weight Loss Ther. 2013 3:182. PMID:
9. DC Kaelber, W Foster, J Gilder, TE Love, and AK Jain. *Patient Characteristics Associated with Venous Thromboembolic Events (VTEs) - A Cohort Study using Pooled Electronic Health Record (EHR) Data*. Journal of the American Medical Informatics Association. 2012 Nov 1; 19(6):965-72. Epub 2012 Jul 3. PMID:22759621. (EDITOR'S CHOICE ARTICLE)
10. LN Baskaran, PJ Greco, and DC Kaelber. *Case Report: Medical Eponyms – An Applied Clinical Informatics Opportunity*. Applied Clinical Informatics. 2012 Sep 19; 3(3):349-55. Print 2012. PMID:23646083.
11. M Ikezuagu, E Yang, A Daghstani, and DC Kaelber. *Implementing Black Box Warnings (BBWs) in Health Information Systems: An Organizing Taxonomy Identifying Opportunities*

and Challenges. Applied Clinical Informatics. 2012 Mar 21; 3(1):124-34. Print 2012. PMID:23616904.

12. RD Cebul, TE Love, AK Jain, and CJ Hebert. *Electronic health records and quality of diabetes care.* N Engl J Med. 2011 Sep 1;365(9):825-33. doi: 10.1056/NEJMsa1102519. PMID:21879900.
13. LJ Benson, HJ Baer, and DC Kaelber. *Screening for obesity-related complications among obese children and adolescents: 1999-2008*. Obesity (Silver Spring). 2011 May; 19(5):1077-82. Epub 2010 Dec 9. PMID: 21151014.
14. LJ Benson, HJ Baer, PJ Greco, and DC Kaelber. *When is family history obtained? - Lack of timely documentation of family history among overweight and hypertensive paediatric patients*. Journal of Paediatrics and Child Health. 2010. Oct; 46(10):600-5. PMID:20626580.
15. LJ Benson, RC Cohn, and DC Kaelber. *The Association of Continuity of Care on the Diagnosis of Hypertension in Children and Adolescents*. Journal of Child Healthcare. 2009 Dec; 13(4):361-9. PMID:19833670.
16. LJ Benson, H Baer, DC Kaelber. *Trend in the Diagnosis of Overweight and Obesity in Children and Adolescents: 1999-2007*. Pediatrics. 2009 Jan; 123(1):e153-8. PMID:19117837.
17. RD Cebul. *Using electronic medical records to measure and improve performance.* Trans Am Clin Climatol Assoc. 2008;119:65-75; discussion 75-6. PMID:18596863.
18. TE Love, RD Cebul, D Einstadter, AK Jain, H Miller, CM Harris, PJ Greco, SS Husak, and NV Dawson; DIG-IT Investigators. *Electronic medical record-assisted design of a cluster-randomized trial to improve diabetes care and outcomes.* J Gen Intern Med. 2008 Apr;23(4):383-91. doi: 10.1007/s11606-007-0454-3. PMID:18373134.
19. ML Hanson, PW Gunn, and DC Kaelber. *Underdiagnosis of Hypertension in Children and Adolescents*. Journal of the American Medical Association. 2007 Aug 22; 298(8):874-9. PMID:17712071.

Abstracts

1. T Dolber and DC Kaelber. *Automatic Phone and Text Message Reminders to Increase Patient Completion of Outpatient Laboratory Testing.* American Medical Informatics Association Annual Symposium Proceedings. San Francisco CA. 2015. (Poster)
2. V Goyal, PJ Greco, and DC Kaelber. *Automating Personal Health Record Mammography Messages to Improve Mammography Screening Rates*. American Medical Informatics Association Annual Symposium Proceedings. San Francisco CA. 2015. (Poster)
3. GJ Kuperman, DW Bates, DC Kaelber, and DA Dorr. *Informatics Approaches to Supporting Emerging Accountable Health Care Delivery Models*. American Medical Informatics Association Annual Symposium Proceedings. San Francisco CA. 2015. (Panel Presentation)
4. E Johnson, WC Baughman, and G Ozsoyoglu. *A Method for Imputation of Semantic Class in Diagnostic Radiology Text*. IEEE International Conference on Bioinformatics and Biomedicine. Washington DC. 2015. (Poster)
5. JK Lee, WC Baughman, R Ferguson, P Greco, and J Siff. *Implementation and Results from Integrated Electronic Health Record Contrast Allergy Decision Support*. Radiological Society of North America Annual Meeting. Chicago IL. 2015. (Poster)

6. PJ Greco and MK Osborn. *A Passive Reminders to Screen for Hepatitis C Virus (HCV) was Highly Effective in Primary Care*. Society of General Internal Medicine Midwest Annual Meeting. Cleveland Ohio. 2015. (Poster)
7. V Jain, PJ Greco, and DC Kaelber. *Code Status Reconciliation to Improve Identification and Documentation of Code Status in Electronic Health.* American Academy of Pediatrics National Conference and Exhibition. Washington DC. 2015. (Poster)
8. E Johnson, MD Torno, and WC Baughman. *Teaching a Machine to Annotate Radiology Text*. Radiological Society of North America Annual Meeting. Chicago IL. 2014. (Poster)
9. E Johnson, WC Baughman, and G Ozsoyoglu. *Mixing Domain Rules with Machine Learning for Radiology Text Classification*. ACM SIGKDD Workshop on Health Informatics (HI-KDD 2014). New York, NY. 2014. (Workshop)
10. R Ferguson, WC Baughman, and J Lee. *Results of Implementation of Integrated Electronic Health Record Contrast Allergy Decision Support*. IEEE International Conference on Biomedical and Health Informatics. Valencia, Spain. 2014. (Poster)
11. M Stager, J Leon, D Bar-Shain, A Runkle, and DC Kaelber. *Improving Adolescent Immunization Rates through Electronic and Non-electronic Direct Patient Communication*. Society for Adolescent Health and Medicine Annual Meeting. Austin TX. 2014. (Poster Presentation)
12. MH Fratantonio, A Masih, M Kauffman, and DC Kaelber. *Data to Dollars – Using Electronic Health Records to Complete Referrals*. American Medical Informatics Association Annual Symposium. Washington DC. 2013. (Abstract Presentation)
13. MA Baker, M Mazza, R Platt, DS Bar-Shain, DC Kaelber, and M Klompas. *Advanced Clinical Decision Support for Vaccine Adverse Event Detection and Reporting*. American Medical Informatics Association Annual Symposium. Washington DC. 2013. (Abstract Presentation)
14. K Palcisco, DC Kaelber, R Cebul, and L Stokes. *Using Electronic Health Record (EHR) Tools to Improve the Screening and Recognition of Depression*. American Medical Informatics Association Annual Symposium. Washington DC. 2013. (Abstract Presentation)
15. K Gourab and DC Kaelber. *Using Big Data for Risk Quantification of Rare Medical Association*. American Medical Informatics Association Annual Symposium. Washington DC. 2013. (Poster Presentation)
16. E Johnson, WC Baughman, and G Ozsoyoglu. *Modeling Incidental Findings in Radiology Records*. ACM Bioinformatics, Computational Biology, and Biomedical Informatics Conference. Sept. 2013. (Poster)
17. MA Baker, DC Kaelber, Megan Mazza, DS Bar-Shain, B Zambarano, P Moro, R Platt, and M Klompas. *Automated Detection and Reporting of Vaccine Adverse Events: ESP-VAERS*. ID Week. San Francisco CA. 2013. (Abstract Presentation)
18. D Bar-Shain, D Kaelber, J Leaon, A Runkle, and P Stager. *Using Electronic Health Record Technologies to Improve Adolescent Vaccination*. Society for Adolescent Health and Medicine, Local Public Health Demonstration Project Summit Meeting. Cincinnati Ohio. 2013. (Platform Presentation)
19. AM Iqbal, DC Kaelber, and MJ Mhanna. *Prevalence and Risk Factors of Hypertension at School Age Among Extremely Low Birth Weight Infants*. Midwest Pediatric Cardiology Society. Chicago IL. 2013. (Poster Presentation)

20. D Bar-Shain, J Leon, P Stager, and DC Kaelber. *Improving adolescent immunization rates through electronic and non-electronic direct patient communication*. Pediatric Academic Societies Meeting. Washington DC. 2013. (Poster Presentation)
21. D Bar-Shain, K Palcisco, PJ Greco, and DC Kaelber. *Using advanced electronic clinical decision support to improve the quality and recognition of abnormal blood pressure values in children*. Pediatric Academic Societies Meeting. Washington DC. 2013. (Oral Presentation)
22. M Callahan, KL Kaelber, DC Kaelber. *Vitamin D Screening and Deficiency among Cerebral Palsy Patients*. Pediatric Academic Societies Meeting. Washington DC. 2013. (Poster Presentation)
23. GQ Zhang, L Cui, J Teagno, D Kaelber, S Koroukian, and R Xu. *Combining Ontology Browsing with Data Exploration: Moving the Needle in Medicaid Data Access*. Clinical Informatics Research Summit. San Francisco CA. 2013. (Poster Presentation)
24. V Patel and DC Kaelber. *Azathioprine – A case study using pooled electronic health record data and co-morbidity networks for post-market drug surveillance*. Clinical and Translational Science Center Annual Informatics Meeting. Chicago IL. 2012. (Poster Presentation)
25. RK Vajravelu and DC Kaelber. *Analysis of voice-transcription software on outpatient charting efficiency*. American Medical Informatics Association Annual Symposium. Chicago IL. 2012. (Poster Presentation).
26. D Bar-Shain, K Palcisco, P Greco, and DC Kaelber. *Clinical Decision Support to Impact the Recognition of High Pediatric Blood Pressure Measurements*. American Academy of Pediatrics National Conference and Exhibition. New Orleans LA. 2012. (Poster Presentation)
27. V Patel and DC Kaelber. *Azathioprine-induced Comorbidity Network Reveals Patterns and Predictors of Nephrotoxicity and Neutrophilia*. The Second IEEE Conference on Healthcare Informatics, Imaging, and Systems Biology. La Jolla CA. 2012. (Oral Presentation)
28. RK Vajravelu and DC Kaelber. *Venous thrombolism risk and anti-tumor-necrosis alpha agents in inflammatory bowel disease and other chronic inflammatory diseases*. American College of Gastroenterology. Las Vegas NV. 2012. (Oral Plenary Presentation)
29. R Waheed, RD Cebul, D Einstadter, D Kaelber, and TE Love. *Health Information Exchange: Adoption by safety-net physicians and their perceptions of cost savings.* Academy Health Annual Research Meeting. Orlando FL. 2012. (Poster Presentation)
30. DC Kaelber, GQ Zeng, and A Jain. *Explorys – A New Paradigm in Integrated Data Repositories: Overview and Case Study*. Clinical and Translational Science Center Annual Informatics Meeting. Washington DC. 2011. (Oral Presentation)
31. A Noto, P Greco, and DC Kaelber. *An analysis of clinical decision support for repetitive urine culturing*. American Medical Informatics Association Annual Symposium. Washington DC. 2011. (Poster)
32. A Jain, D Kaelber, J Gilder, D Meil, and C Lougheed. *A Sustainable Platform for Data Sharing in Multi-Institutional Population-Based Clinical Research*. American Medical Informatics Association Annual Symposium Proceedings. Washington DC. 2011. (Poster)

33. MM Del Toro, AK Avery, PJ Greco, and DC Kaelber. *Electronic Health Records (EHRs): A Role in Eliminating Disparities in HIV Testing*. American Public Health Association. Washington DC. 2011. (Oral Presentation)
34. MM Del Toro, AK Avery, PJ Greco, and DC Kaelber. *Enhancing HIV Testing Practices: Routinizing Testing through Electronic Medical Record (EMR) Technology*. National HIV Presentation Conference. Atlanta GA. 2011. (Oral Presentation)
35. MM Del Toro, AK Avery, A Caron, PJ Greco, and DC Kaelber. *Enhancing HIV Testing Practices: Routinizing Testing through Electronic Medical Record (EMR) Technology*. National HIV Presentation Conference. Atlanta GA. 2011. (Oral Presentation)
36. G Kaur and DC Kaelber. *From Diagnosis to Follow-up - Getting Pediatric Patients with Weight Problems followed in a Pediatric Weight Management Program*. Pediatric Academic Societies Meeting. Denver CO. 2011. (Poster)
37. T Gurevich-Panigrahi, S Kausik, S Akers, R Needlman, and DC Kaelber. *One-Year Outcomes in a Longitudinal Pediatric Weight Management Program*. Pediatric Academic Societies Meeting. Denver CO. 2011. (Poster)
38. NP Iyer, M Lazbin, D Kaelber, and A Ghori. *Self-Developed Electronic Sign Out Format to Ensure Safe Transfer of Patient Care.* Association of Pediatric Program Directors Annual Meeting. Miami FL. 2011. (Poster)
39. KR Schlosser and DC Kaelber. *The Timing and Link between Development of Hypertension and Overweight in Children – A Cohort Study*. Circulation. 23 November 2010; 122: A18127. (Poster)
40. N Pashmini, CGallaspie, E Clegg, N Fishburn, and DC Kaelber. *Internet Access and Use among Lower Socio-Economic Status Populations.* American Medical Informatics Association Annual Symposium Proceedings. Washington DC. 2010. (Poster)
41. E Lucas, T Joyner, J Conti, M Chase, J Hanrahan, and DC Kaelber. *Bacterial colonization of hospital computer keyboards and the effect of keyboard covers.* American Medical Informatics Association Annual Symposium Proceedings. Washington DC. 2010. (Poster)
42. EM Hinz and DC Kaelber. *Clinician Characteristics and their Association with Efficient Electronic Health Record Documentation*. American Medical Informatics Association Annual Symposium Proceedings. San Francisco CA. 2009. (Poster)
43. M Ikezuagu, E Yang, A Daghstani, and DC Kaelber. *An Informatics Oriented Taxonomy for Black Box Warnings (BBWs)*. American Medical Informatics Association Annual Symposium Proceedings. San Francisco CA. 2009. (Poster)
44. LJ Benson, H Baer, and DC Kaelber. *Using Electronic Medical Records to Study Guideline Compliance: Screening for Pediatric Obesity Co-Morbid Conditions*. American Academy of Pediatrics National Conference and Exhibition. Washington DC. 2009. (Poster)
45. LJ Benson, HJ Baer, PJ Greco, and DC Kaelber. *Using Electronic Medical Records to Study Pediatric Practice Patterns - The Timeliness of Family History Documentation.* American Academy of Pediatrics National Conference and Exhibition. Washington DC. 2009. (Poster)
46. LJ Benson, RC Cohn, and DC Kaelber. *Continuity of Care and Diagnosis of Pediatric Hypertension*. Pediatric Academic Societies Meeting. Baltimore MD. 2009. (Poster)
47. M Clark, M Stager, and DC Kaelber. *BMI Percentile in a Cohort of Urban Children Pre and Post Puberty*. Pediatric Academic Societies Meeting. Baltimore MD. 2009. (Poster)

48. DC Kaelber, V Miller, N Fisher, J Schlesinger, and G Norris. *Ambulatory Electronic Medical Record Payback Analysis 7 years after Implementation in a Tertiary Care County Medical System*. American Medical Informatics Association Annual Symposium Proceedings. Chicago IL. 2007. (Poster)
49. PW Gunn, ML Hanson, and DC Kaelber. *Underdiagnosis of Pediatric Hypertension. - An Example of a New Era of Clinical Research Enabled by Electronic Medical Records.* American Medical Informatics Association Annual Symposium Proceedings. Chicago IL. 2007. (Poster)
50. DC Kaelber, ML Hansen, and PW Gunn. *Underdiagnosis of Pediatric Hypertension – An Example of the Potential of Electronic Medical Record Research for Clinical Pediatricians*. American Academy of Pediatrics National Conference and Exhibition. San Francisco CA. 2007. (Oral Presentation)
51. R Magliola and DC Kaelber. *SharePoint – An Effective and Efficient Method to Share Digital Medical Information Resources among Residents.* Society of General Internal Medicine Meeting. Toronto CA. 2007. (Poster)
52. ML Hansen, PW Gunn, and DC Kaelber. *Under-detection of Hypertension in Children*. Pediatric Academic Societies Meeting. Toronto CA. 2007. (Oral Presentation)
53. M Auron-Gomez, S Ibrahim, S Snow, R Needlman, RC Cohn, and DC Kaelber. *Weight Related Co-morbid Conditions in Overweight Children – What Are We Missing?* Pediatric Academic Societies Meeting. Toronto CA. 2007. (Oral Presentation)
54. V Allareddy, VA Allareddy, and DC Kaelber. *Comparing Perceptions and Use of a Commercial Electronic Medical Record (EMR) between Primary Care and Subspecialty Physicians*. American Medical Informatics Association Annual Symposium Proceedings. Washington DC. 2006. (Poster)
55. ND Krause, GD Roulette, KK Papp, and DC Kaelber. *Assessing Medical Informatics Confidence among 1st and 2nd Year Medical Students.* American Medical Informatics Association Annual Symposium. Washington DC. 2006. (Poster)
56. DC Kaelber, P Greco, RD Cebul. *Evaluation of a Commercial Electronic Medical Record (EMR) by Primary Care Physicians 5 Years after Implementation*. American Medical Informatics Association Annual Symposium. Washington DC. 2005. (Poster)
57. DC Kaelber, S Grove, C Dziedzina, R Cohn, D Bar-Shain and M Richard. *A Pediatric PDA (Personal Digital Assistant) Program for Residents.* Pediatric Academic Societies. Seattle WA. 2003. (Poster)