Case Study - Clinical Value
University of California Davis Health System
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2012 National Patient Safety Goals and National Priorities Partnership Goals addressed by case study:

<table>
<thead>
<tr>
<th>Number</th>
<th>Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPSG.07.04.01</td>
<td>Use proven guidelines to prevent infection of the blood from central lines.</td>
</tr>
<tr>
<td>NPSG.07.05.01</td>
<td>Use proven guidelines to prevent infection after surgery.</td>
</tr>
<tr>
<td>NPSG.07.06.01</td>
<td>Use proven guidelines to prevent infections of the urinary tract that are caused by catheters.</td>
</tr>
<tr>
<td>NPP Goal</td>
<td>Improve the safety and reliability of America’s health care system.</td>
</tr>
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</table>

Executive Summary
The UC Davis Health System (UCDHS), an integrated academic health system, consists of the UC Davis School of Medicine, the Betty Irene Moore School of Nursing, the UC Davis Medical Center and Children’s Hospital, and the UC Davis Faculty Practice Group. UCDHS has over 7,700 faculty and staff, including 1,300 physicians and 1,500 registered nurses. The Health System delivers primary, secondary and tertiary care through a 619-bed fully accredited hospital with a Level I trauma center, with over 30,000 annual admissions, and 100-plus specialty and primary care clinics supporting more than 900,000 outpatient visits per year. UCDHS serves a large population throughout inland Northern California that includes a 33-county, 65,000 square mile area of more than six million residents, comprised of a highly diverse patient population.
1. Background knowledge
The deployment of the electronic health record (EHR) has emerged as one of the most transformative events in the history of the UC Davis Health System (UCDHS). The EHR has been leveraged to transform clinical care, quality and safety programs, content governance, and support of clinicians. This transformation has become the new foundation of care delivery for the organization and provides sophisticated tools to create transparent, reliable, and safe practices in the care of patients. While deploying the EHR, UCDHS redesigned many clinical workflows and added evidence-based knowledge to EHR tools such as order sets, alerts, and innovative clinical surveillance programs. Data and tools in the EHR are used in updated clinical workflows to create and manage clinical improvements defined by the National Patient Safety Goals and other targets. The Epic EHR is used comprehensively across all UC Davis care delivery venues including inpatient, emergency, ambulatory, home health, and telemedicine. The EHR currently manages 2.2 million patient records and has over 350 million clinical observations spanning more than a decade.

2. Local problem being addressed and intended improvement
Clinical Quality Improvement
UCDHS management recognized that care quality improvement efforts supported by manual paper chart audits, batch reports, and traditional methods of disseminating evidence-based best clinical practice did not 'move the needle' toward improved quality in the way intended. The EHR was essential to improving clinical care and achieving quality improvement goals.

Sepsis Rate
One of the major clinical problems that needed to be addressed was the sepsis rate. UCDHS had been experiencing about 40 - 80 cases of sepsis and septic shock in the ICU each month. Of these patients, the observed mortality rate was 25 – 33%. The team faced this problem directly and crafted an initiative for change. The EHR was essential to making that change possible. The lives of 10 to 20 patients per month depended on it. The initial goal of the sepsis improvement initiative was to leverage the EHR to improve sepsis-related mortality by 15% by 2013.

Other Goals to be Addressed
In addition to reduction in the rate of sepsis, quality improvement initiatives were focused on the NPSG goals in order to reduce the rates of:
- Catheter associated urinary tract infection (CAUTI)
- Central line bloodstream infection (CLBSI)
- Ventilator associated pneumonia (VAP)
- Narcotic overdoses
- Hypoglycemic episodes

The UCDHS approach was to create an organizational level dashboard based on EHR content for the National Patient Safety Goals. This dashboard would keep the organization focused on our clinical improvement goals and would be populated by data that the EHR could provide.

3. Design and Implementation
UCDHS used a five step process to implement the EHR to optimize clinical value.

1. Step one - create a clinical governance structure for EHR implementation. During implementation, the existing Medical Records Committee (MRC) was transformed to become a multidisciplinary, cross-venue, clinical governance committee for EHR-related decisions and policies. An EHR medical director was appointed chair of this committee, and the committee
recommended standardized design decisions and upgrades, as well as new medical staff policies needed to optimize an EHR-enabled environment. The Committee ensured implementation decisions were clinician friendly, safe for patient care, and technically feasible.

2. Step two - develop broad informatics expertise. Five medical directors were selected with expertise in primary care, hospital medicine / infectious diseases, surgery, residency programs / education, pediatrics, and intensive care medicine. The health system provided salary support, defined deliverables and provided resources to ensure their success. During the implementation process, these medical directors assisted in implementation design decisions and partnered with faculty representatives and RNs from each clinical department to ensure requirements were met.

3. Step three – design and implement reliable and standardized clinical workflows. UC Davis leadership and committee groups allowed time for adequate EHR adoption; ensuring clinicians had time and support to adjust to new workflows and the EHR, and ensured clinicians had enough time to make local adjustments as needed.

4. Step four - transform safety and quality programs. As the implementation of the EHR progressed, UCDHS quality and safety programs were redesigned to leverage the benefits of the EHR. As all clinical content became available in the EHR, electronic views (new reports, dashboards, registries) of the entire health care process became possible in near real-time.

5. Step five - align health system goals and empower clinicians with EHR functionality. After implementation of the foundational EHR tools (clinical results, order entry, online clinical documentation) and ensuring all organizational clinical content was loaded or linked to the EHR, the focus shifted to leverage the EHR to achieve organizational goals (such as improving clinical coding and charge capture) and also support industry goals (such as the National Patient Safety Goals and HITTECH EHR meaningful use requirements). By adding population databases (Tethered Meta Registries - TMR) and customized reporting, organizational focus shifted to empowering clinicians to deliver optimal patient care, link care with research as relevant, and enhance clinical education.

UCDHS now uses a care quality improvement program that is fully electronic; leveraging patient level data in the EHR and population data in the TMR. A key element in the success of UCDHS in deploying and leveraging the EHR has been very strong clinician engagement and support. There are 48 physicians and 2 nurse practitioners who comprise the ‘hospital and specialty EHR champions group’. There are also six funded EHR medical director positions providing more in-depth informatics support. These physicians act collectively as the equivalent of a chief medical information officer.

4. How was Health Information Technology (IT) Utilized?

UCDHS uses a wide variety of technology to support clinical care. The primary software applications used to drive clinical workflow change and improve outcomes are the EpicCare EHR, the TheraDoc infection control assistant, and the TMR. UCDHS has also deployed a growing list of specialized health exchange technologies that securely move patient records within UC Davis, mutually share data with other unaffiliated care providers in the region.

- The EHR supports a broad array of clinical encounters.
  - 94.6% of clinical orders entered via CPOE (TPN orders will go online within a year)
  - 761 online EHR clinical order sets in use
  - 212 EHR based chemotherapy protocols support 575 patients on active protocols
  - Over 528 EHR clinical documentation templates in use
- 93.5% of inpatient & 91.54% of ambulatory clinical notes created through EHR templates
- Over 335 physicians use voice recognition to create documentation in the EHR
- The TheraDoc Infection Control assistant supports real-time electronic surveillance and clinical decision support tools to support infection control and drug related safety tasks.
- UCDHS has created many real-time interfaces to load EHR and other clinical data to TheraDoc’s specialized knowledge base and software functionality: medication orders, device line data, vital signs, surgery case summaries, suppressed microbiology susceptibilities, outpatient tagging of lab results, and other clinical documentation.
- The Tethered Meta registry (TMR) has been created by UC Davis using the Remedy Informatics registry product, Oracle, various data visualization tools, several data loading/interface tools, and an open source portal product from LifeRay.
  - By ‘tethering’ the Meta registry to the EHR, all 2.2 million patients in the UCDHS EHR are loaded, along with a growing list of specialized data elements from legacy registries and other clinical technology such as data captured directly from CT scanners (Radiation Dose).
  - Early versions of the TMR have targeted different types of registries (cohorts), to test and adapt the software to different needs. The initial list of registries created include; burn, cancer, sepsis, diabetes, medical home and CT Radiation Dose (a new type of registry that captures radiation dose measurement (using Radimetrics software) at the organ level in a registry subset of all patients who received a computed tomography (CT) scan).

“Electronic Breadcrumbs”
An example of the real-time surveillance created in the EHR is the concept of ‘electronic breadcrumbs.’ These start as rules in EHR order sets and alerts, and are incorporated into clinical workflows. The breadcrumbs are critical data points that equate with clinical goals and help surface and measure trends and events that either support reaching a clinical goal for a patient or indicate an impending clinical problem that must be addressed. These electronic markers can quickly be shared with the care team without the delay of manual abstraction. The point of these markers is to create actionable alerts and metrics in real-time so clinicians can intervene in patient care in time to achieve the desired clinical outcome.

For example, in the initiative to reduce sepsis in the ICU, the “breadcrumbs” act as reporting signals to identify and trace potential sepsis patients. These “breadcrumbs” are the markers that the EHR recognizes, and they serve to provide immediate alerts to nursing staff to identify patients who are at high-risk of sepsis, and to begin the final diagnostic protocol and treatment regimen for those patients who need prompt intervention in order to reduce the risk of morbidity or mortality. A graph depicting the trend in reduction of sepsis following the EHR implementation can be found in the Appendix.

This breadcrumb approach is also being used to track adverse events related to a range of conditions such as narcotic overdoses and hypoglycemic episodes. They are now digitally detected by analyzing EHR content for the use and administration of reversal agents for narcotics and treatments for hypoglycemia. Utilization of ventilators and central lines are measured in the same manner, as well as critical lab values. The breadcrumbs are further strengthened by linking them with hospital policy and standards of care that support prompt response to problems when they arise.

September, 2013
5. Value Derived/Outcomes
The value of the EHR and other clinical software tools to UC Davis clinicians creating quality improvement is significant. The chart of 10 metric examples of clinical quality improvement in Table 1 in the Appendix demonstrates the breadth of the impact UCDHS quality improvement teams are achieving through use of the EHR. With earlier recognition and aggressive standardized management, average ICU length of stay steadily decreased, resulting is significant costs savings as displayed in the Appendix. The graph below depicts how quality improvement initiatives are saving lives.

**Sepsis Initiative**
As described above, in 2009, a major goal of the ICU team was to reduce sepsis by 15% by 2013. With very careful planning, the team made the assessment that the EHR could provide the technological capability to manage sepsis with a new paradigm. With the ‘breadcrumbs’ generated by the EHR, clinicians finally had the tools to identify patients at risk of sepsis, to monitor those patients in real time, and to intervene immediately with the onset of the infection. In 2011 54 lives were saved; and mortality was reduced by 25% over the 2009 baseline. The reduction in sepsis exceeded the 15% goal set for achievement by 2013. A graph depicting the trend in reduction of sepsis following the EHR implementation can be found in the Appendix.

**Ventilator Associated Pneumonia in the Pediatric ICU**
These broad improvements in clinical outcomes are ‘moving the needle’ toward improved performance and often in dramatic fashion. For example, in less than 36 months, a program that uses the EHR to reduce ventilator associated pneumonia (VAP) in the UCDHS pediatric ICU has decreased the rate of VAP from an average of 5.34 per 1000 patient days in CY 2010 to 0.60 in CY 2012, an 82% reduction. This is one of the most dramatic improvements in quality of care in recent institutional memory. Most importantly, given the strong partnerships created, new clinical workflows defined and embedded in the EHR, and the creation of best practice online clinical knowledge in the EHR; these improvements have demonstrated to be sustainable.

September, 2013
Other Clinical Quality Improvements
Highlights of clinical quality improvements achieved with the support of the EHR from 2010 to 2011 include:
- Decrease of 44.4% in central line bloodstream infections
- Decrease of 8.6% in catheter associated urinary tract infection
- Reduction of 65.9% in surgical site infection

For UC Davis, this is only the beginning. With the knowledge and experience of how to set clinical targets and create effective and sustainable interventions to measurably improve care (“moving the needle”), clinicians and IT staff are busy extending this approach to more quality goals and types of care.

An example of how the ‘needle is moved’ to improve clinical outcomes in the new EHR enabled care environment at UC Davis is an email sent on July 31st by Dr. Siefkin, the Chief Medical Officer, at the UC Davis Medical Center. The email notes an earlier increase in compliance to 85% for daily clinical review and documentation of central line necessity, and when the CMO sees the needle slide back down, he can quickly share this message and take other steps to address a negative trend, including drilling down into the data to learn more about what has changed and where focus should be directed.

For a physician leader to have ‘daily monitored results’ for a key clinical goal such as reducing central line bloodstream infections (CLBSI) for the entire inpatient population in a large academic medical center, and be able to quickly send a message (he can send an email or an EHR inbox alert) to all faculty physicians and residents; would have been unthinkable – until this past year. The EHR and Tethered Meta Registry were essential in creating this new capability.

6. Lessons Learned
Create a dashboard to set priorities driven by improved quality outcomes: In order to drive adoption of EHR-based quality performance measures, it is critical that a healthcare system create an organizational level dashboard with quality measure scores on each of the National Patient Safety Goals. In order to effectively drive process change, dashboards must:
- Provide data in real time
- Data must be actionable, and accurate
- There must be clearly defined roles using the data to make it pertinent to the front line clinician
- An educational / training component is critical to drive workflow and help clinicians adapt to EHR changes. Early in our sepsis initiative, clinicians were skeptical of the EHR tools that were meant to help recognize and manage severe sepsis patients. Using real patient cases, UC Davis clinical leadership highlighted cases where failure to respond to EHR alerts

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indicating early onset of sepsis could potentially lead to death. As result of this top-down emphasis of alert and order set utilization, physician compliance increased dramatically.

Create a collaborative distributed and shared model of clinician informatics leadership that involves all clinical elements of the organization: We learned early in our implementation that when using a singular EHR across the enterprise, any changes customization to the EHR or new workflow that helps one group of clinicians could potentially have a negative impact on another group of end-users.

Through the creation of a multidisciplinary, cross-venue, clinical governance committee for EHR-related decisions included department and service level representatives were asked to represent the needs of their department, all decisions involving changes in the EHR and workflows were vetted by representatives of all end users. As result, any changes in workflow were reviewed by representatives of all departments, and those departments were kept abreast of any developments that could potentially change care delivery.

A new focus and passion for 'data curation' has been created at UC Davis. It is now understood that the quality of the data in some of the key legacy clinical software applications was generally poor. Going forward the quality of clinical data an organization creates will be critical to its survival. Clinical data will be the basis to manage care and quality, increasingly impact reimbursement, and will be shared with other care providers in the community. Increased data transparency across the healthcare industry will make an organizations poor quality clinical data obvious to all.

7. Financial Considerations

UC Davis Medical Center has invested an estimated $160 million in capital costs from 2002 and planned through 2013, to deploy clinical information technology. Yearly operational costs are approximately $31 million per year. Line item detail is provided in the UC Davis Return on Investment Davies Case Study.

UC Davis is using evidence-based studies to measure and calculate the financial benefit of improved care, and the organization is gaining sophistication in measuring the financial impact of improving quality. The EHR helps lock-in care process improvements to create routine improved clinical and cost outcomes. A study conducted by the Center for Evidence-Based Practice at the University of Pennsylvania (Umschied, 2011) estimates the proportion of healthcare-associated infections that are reasonably preventable and the related mortality and costs associated with those adverse events demonstrate significant impact of the EHR to UC Davis:

- CAUTI - $4000/infection and a 2.3% mortality reduction / prevented infection
- CLBSI - $21,400/infection and 12% mortality reduction/ prevented infection
- VAP - $23,000/infection and 14.4% mortality reduction/prevented infection

In a future where the cost of care won’t be reimbursed when a ‘never event’ occurred, and clinical quality metrics will have increasing impact on reimbursement levels, improving the quality of care is not only the right thing to do for patients, but is required for the financial viability of a care providing organization.

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### Table 1: Examples of clinical quality improvement

<table>
<thead>
<tr>
<th>#</th>
<th>Quality Metric</th>
<th>2010 Rate</th>
<th>2011 Rate</th>
<th>2012 Rate</th>
<th>% Change 2010-12</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Central Line Bloodstream Infection*</td>
<td>3.04</td>
<td>2.34</td>
<td>1.69</td>
<td>-44.4%</td>
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<tr>
<td>2</td>
<td>Catheter Associated Urinary Tract Infection*</td>
<td>3.71</td>
<td>2.79</td>
<td>3.39</td>
<td>-8.6%</td>
</tr>
<tr>
<td>3</td>
<td>Ventilator Associated Pneumonia*</td>
<td>8.34</td>
<td>5.92</td>
<td>8.00</td>
<td>-4.1%</td>
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<tr>
<td>4</td>
<td>Surgical Site Infection (Standardized Infection Ratio)</td>
<td>1.35</td>
<td>0.63</td>
<td>0.46</td>
<td>-65.9%</td>
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<tr>
<td>5</td>
<td>Inpatient Mortality Index (Observed / Expected)</td>
<td>1.07</td>
<td>0.86</td>
<td>0.83</td>
<td>-22.4%</td>
</tr>
<tr>
<td>6</td>
<td>All Sepsis Mortality (% Deaths Observed)</td>
<td>16.91%</td>
<td>12.40%</td>
<td>12.58%</td>
<td>-25.6%</td>
</tr>
<tr>
<td>7</td>
<td>30 Day Readmission to Same Hospital (Heart Failure)</td>
<td>12.08%</td>
<td>9.09%</td>
<td>7.64%</td>
<td>-36.8%</td>
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<tr>
<td>8</td>
<td>PICU Central Line Bloodstream Infection*</td>
<td>8.44</td>
<td>4.44</td>
<td>2.20</td>
<td>-73.9%</td>
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<tr>
<td>9</td>
<td>PICU Catheter Associated Urinary Tract Infection*</td>
<td>7.00</td>
<td>1.68</td>
<td>3.38</td>
<td>-51.7%</td>
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<tr>
<td>10</td>
<td>PICU Ventilator Associated Pneumonia*</td>
<td>8.79</td>
<td>4.74</td>
<td>1.58</td>
<td>-82.0%</td>
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</tbody>
</table>

*Average yearly rate per 1,000 device days

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**Example Dashboard from UCDHS Tethered Meta Registry (TMR)**

Summary TMR-based Sepsis dashboard that is shared with all UCDHS clinicians and care teams

Shows number of patients with severe sepsis/septic shock, mortality rate, and total compliance with all sepsis best-practice care bundles

The TMR creates unique population clinical data from EHR for relevant populations to clinicians

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**End Notes**

Control chart to show the reduction in sepsis mortality rate by calendar year for 2009 through June 2013

With earlier recognition and aggressive standardized management, average ICU length of stay steadily decreased, resulting in significant costs savings.
Reduction in CLABSI YTD mean rate
For Pediatric Intensive Care Unit

The YTD mean rates in both graphs are compared to the US Centers for Disease Control (CDC) National Healthcare Safety Network benchmarks

Reduction in VAP YTD mean rate
For Pediatric Intensive Care Unit

2010 - 2012

2010 - 2012