HIMSS Davies Enterprise Award Submission –
Innovative Utilization of RFID Bar Code Administration

Applicant Organization:	St. Clair Hospital
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Menu Item:	Innovation
National Priorities Partnership:	Safety: Improve liability and eliminate errors wherever and whenever possible
National Patient Safety Goal:	Improve the safety of medications

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Executive Summary:

Preventable medication ordering and administration errors are perhaps the most prevalent errors occurring in hospitals today and represent a significant risk to patient safety. The prevalence is easily understood as the medication-use process is complex, involving prescribing, dispensing, administration, and charting medications. Errors can occur in order entry, patient identification, medication identification, doses, routes, and timing. Considering this complex process, St. Clair Hospital established a multidisciplinary team to ensure the safe delivery of medication, utilizing technology to reduce the likelihood of human error. A two-pronged approach was used including enhanced decision support capabilities for the medication ordering process in the EHR, and development of a handheld system to integrate with the core EHR to prevent medication administration errors at the bedside.

Results include:

- Developed and deployed a dual scanning technology, barcode and RFID, to facilitate change management and technology adoption by nursing personnel
- Sustained a 96% adoption rate for use of the handheld device for the medication administration process over a multi-year period
- Since 2004, over 1,100 avoidable errors annually have been prevented
- Achieved real-time automated charting of medication administration to the electronic medication administration record (eMAR)
- Dramatically improved patient safety for anti-coagulation therapy
- Demonstrated a dramatic ROI associated with this EHR project

Background Knowledge:
St. Clair is a 328-bed independent, acute care facility that provides advanced, high quality health care to more than 480,000 residents in southwestern Pennsylvania. Our mission is to provide highly valued, service-oriented healthcare to our community across its main campus and five outpatient centers.

The Hospital's Patient Safety Committee had historically presented their monthly findings on medication administration occurrences. The committee continually advocated the use of computerized systems and technology to help prevent errors. Below is a brief history.

- In 1990, the Hospital installed it first CPOE-enabled EHR system.
- In 1992, the Hospital installed the industry's first robotic drug distribution system for automated dispensing of bar-coded medications, and had virtually eliminated all dispensing errors. However, medication ordering and administration errors continued to occur.
- In 1997, the IT department received approval to develop a handheld scanning device to be used at the bedside to scan the patient's ID and then scan the meds to ensure a match. Although the scanning technology worked well, the unit was not reliable on the wireless network.
- In 1999, the "To Err is Human" report was published by the Institute of Medicine (IOM) shedding light on the medication administration problem and calling for a national effort to make healthcare safer. In 2003, with advances in handheld devices and wireless networks, the hospital IT department revived the mobile handheld development project.
- In 2008, the Hospital began focused efforts to improve the safety of anticoagulant therapy. As high-risk medication, anticoagulants can be prone to error-related adverse events. Safeguards were developed by embedding clinical decision support into the EHR.

Local Problem and Intended Improvement:
Given the evidence of medication errors at the hospital, and the knowledge of some under-reporting of near misses, the situation clearly called for a technological solution.The primary improvement sought was a system that would reduce the number of preventable medication administration errors, while improving other clinical outcomes. The goal was to design the EHR system to include extensive decision support for medication ordering, and supply nurses with mobile handheld wireless technology to ensure safety at the point of administration. With accurate and appropriate medication orders in the system, and nurses performing the 5 Rights (patient, drug, dose, route, and time) of medication administration, it was felt that errors would be reduced and quality would be improved. The decision was made to address medication administration error prevention first, and address medication ordering errors second.

Design and Implementation:
The interdisciplinary team worked to complete the design parameters and the hospital's internal software development team coded the meds verification application to perform the 5 rights of medication administration and augment the EHR. The new capabilities were deployed on a wireless handheld device that displayed the medication orders in the EHR. When it is time for the nurse to administer medications, the nurse uses the handheld, selects a patient from

the list, and scans their own ID badge. The device is then used to scan the bar-coded medications and verify that there is an exact matching order for that medication. The nurse then scans the patient ID band to make sure that they are at the bedside of the correct patient for the medications in hand. After administration, the handheld system transmits the administration records and observations to the eMAR.

In 2004, after an initial pilot on 3 units and some revisions to the workflow, the application was fully deployed to 16 nursing units over an 8-month period.

How Health IT Was Utilized:
Each and every action performed on the handheld device was logged to the database. In order to measure the impact that the new technology was having on preventing avoidable errors, the records in the database were mined and analyzed after each year of use. Three (3) years worth of the results are shown in the table.

Type of Med Errors Prevented	Average Number of Errors Prevented per Week per Nursing Unit		
	2004	2005	2006
Medication not ordered for this patient and nurse attempted to administer	1.41	.69	.68
Medication discontinued by physician for this patient and nurse attempted to administer	.49	.25	.38
Wrong patient scanned for the medication being administered	.30	.42	.39
Annual Rate of Errors Prevented	1,830	1,131	1,206

After thorough analysis of the data, several conclusions were drawn. First, preventable errors occur at alarming rates. Second, for regular users of the handheld system, the rate of wrong-med error prevention decreases over time because, through alerts presented to the nurse, the device teaches the nurse to avoid the opportunity for error. New users of the system, on average, commit errors at a higher rate because they have not yet learned to avoid errors. Third, when hospital bed census and patient transfers increase, the number of wrong-patient errors increases.

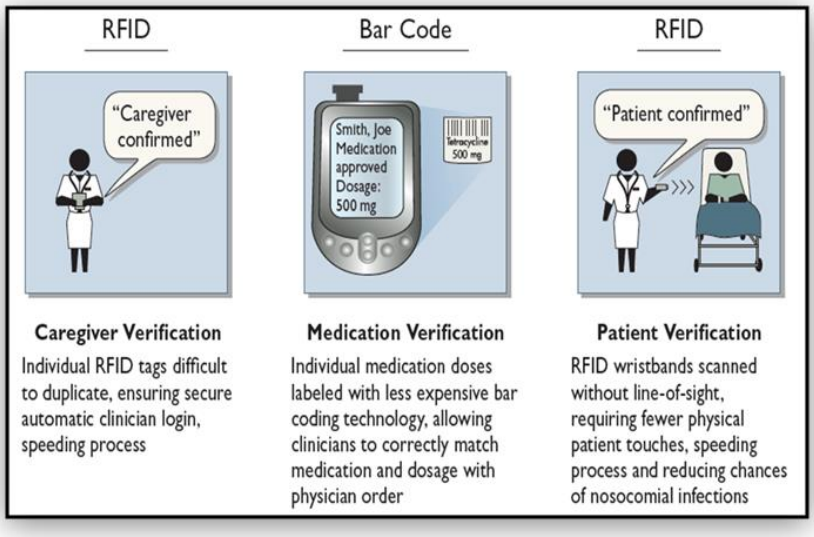
After 2006, the rate at which error preventions occurred began to level out. It became apparent that a certain amount of human error would remain in the process, and only a technological aid, such as the handheld device, could prevent errors. Even when the rates were spot checked in subsequent years, the rate of error prevention remained significant. There was internal debate on whether the desired trend of error prevention should be up or down. Those who wanted it to go down argued that a downward trend would indicate that nurses were committing fewer errors. Those who felt it would be better to see the rate going up argued that an upward trend would indicate that more errors were being prevented and not reaching the patient. Regardless of which view was correct, the team decided to shift the focus from monitoring error prevention rates, to measurement of adoption rates, as the system was clearly valuable but had not yet achieved full voluntary adoption by nursing. It is worth pointing out that there is a difference between the tracking of prevention rates associated with the use of handheld scanning technology, and the tracking and reporting of medication occurrences. The

differences are shown in the table below, and it is important to note that medication occurrence reporting at St. Clair is a continuous process that is reported on monthly.

Medication Occurrence Reporting	Medication Error Reporting from Handheld Scanning System
• Self-reported into the incident tracking system	• Captured as part of the medication administration process
• Includes near misses and errors that reach the patient.	• Focused on error prevention. Includes only near misses. Includes only 5-Rights.
• Collected and reported on every year through 2014. Continuous tracking is necessary.	• Collected from 2004 through 2014. Reported on in 2004, 2005, 2006, and FY2014. Rely on technology to prevent errors, so not reported on each year.

Seeing that the use of the technology has a dramatic impact on avoiding errors, nurses were asked why they would choose to give medication without using the mobile device. The answer was always the same – the scanning process takes extra time. The project team conducted end-to-end timing studies and concluded that use of the mobile device was roughly time-neutral. However, even after sharing the findings, the perception among nurses persisted, and it became evident that nurses wanted the scanning process to be more convenient.

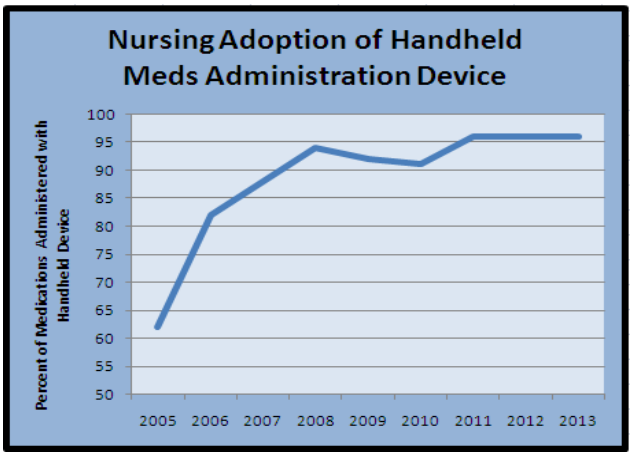
In 2005, the team began to develop a more convenient scanning technology. Nurses could easily scan bar coded medications with a simple point and shoot action, but scanning patient wristbands and scanning their own ID badges, was a little more difficult. To make these scanning tasks easier, the team partnered with a mobile device and peripheral maker, and co-developed a dual bar-code and RFID scanner for use in the mobile device. The most difficult task was finding the optimal RFID scanning distance. In a semi-private room, it is imperative to have the scanner read the wristband of the intended patient, and not the patient in a neighboring bed. Equally important was finding ways to perform RFID scans without draining the battery. A read distance of 3" – 4" was adopted.



Once the design was perfected, the dual scanner allowed the nurse to press a button for a bar-code scan of the medication, and use a different button to perform a RFID scan of the patient wristband and their own ID

badge. The workflow is shown in figure.

The voluntary nursing adoption rate of the handheld medication verification system was 62% in 2005. As shown in the figure, in January of 2006, the dual barcode and RFID scanner was deployed on three (3) pilot nursing units. The adoption rate of the handheld on those three (3) units leaped to 97.5%. Based on this favorable reaction to the dual scanner, plans were made to deploy the scanner house wide. Throughout 2007, the dual scanner was deployed to all nursing units.



In the 2009 time period, after two (2) years of RFID use, it was determined that the dual scanner technology was not durable enough for the rigors of use on a nursing unit, and as breakage rates increased, adoption began to decline slightly. By 2010, the dual scanners were replaced with a more ruggedized device. Despite the fact that the new device had only a barcode scanner, nursing adoption of the handheld device returned to its highest levels and remains there. This is because the culture had changed and use of the medication verification system was embraced and had become the only acceptable workflow for nurses. With this high level of sustained adoption, medication administration errors are held to a minimum level.

In the 2008 timeframe, the team was finally able to turn its attention to embedding clinical decision support tools into the ordering process of the EHR. Since the beginning of the multi-year project, the team recognized that to maximize safety the 5 rights system and EHR must work in tandem. Improving the safety of anti-coagulation therapy was the first priority as the ordering process is laden with the potential for error. Without the enhanced EHR logic to ensure the medication is properly ordered, the value of the proper administration is diminished. After administration, the EHR again has to track and monitor the therapy so that subsequent doses are calculated properly.

Heparin infusion orders were newly divided into two (2) order sets: an initial order set intended to be used at the beginning of heparin therapy, and a maintenance order set, intended for ongoing therapy and dose adjustments based on aPTT/INR results. An initial order set can only be entered once. Clinical decision support logic prevents the prescriber from entering an initial order set if the patient has already had a maintenance protocol ordered. Conversely, a prescriber cannot order the maintenance protocol unless the initial order set has previously been entered. Upon accessing the electronic order set, the end user is presented with pre-populated data elements. The patient's weight and aPTT results are auto-populated, which then provides a heparin dosage suggestion and recommended rate adjustments.

Prescribers are also presented with alerts whenever an additional bolus dose of heparin is required per protocol and has not been entered.

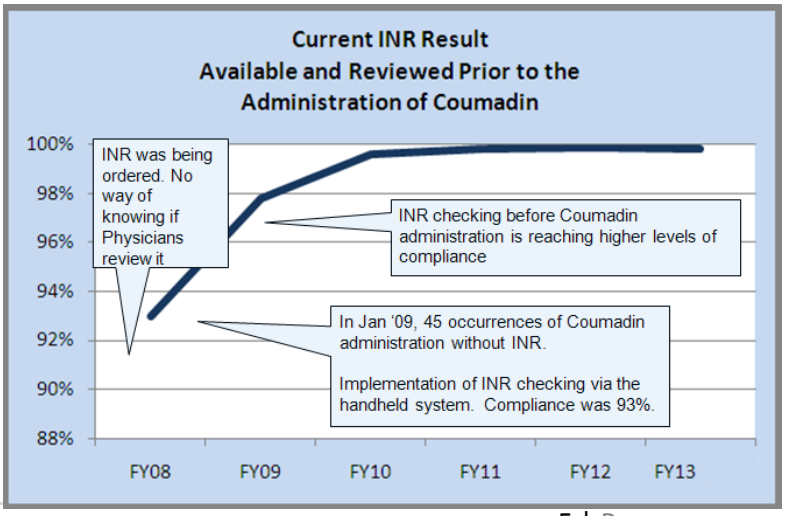
Standardized lab monitoring was accomplished in the EHR by auto-generating appropriate lab orders once the prescriber selects an order for heparin. A baseline INR, followed by a daily INR is auto-ordered when Coumadin is ordered. Heparin orders auto-generate a baseline CBC and then an every 48-hour CBC. Lovenox and Arixtra generate baseline CBC and serum creatinine levels and then an every 48-hour CBC.

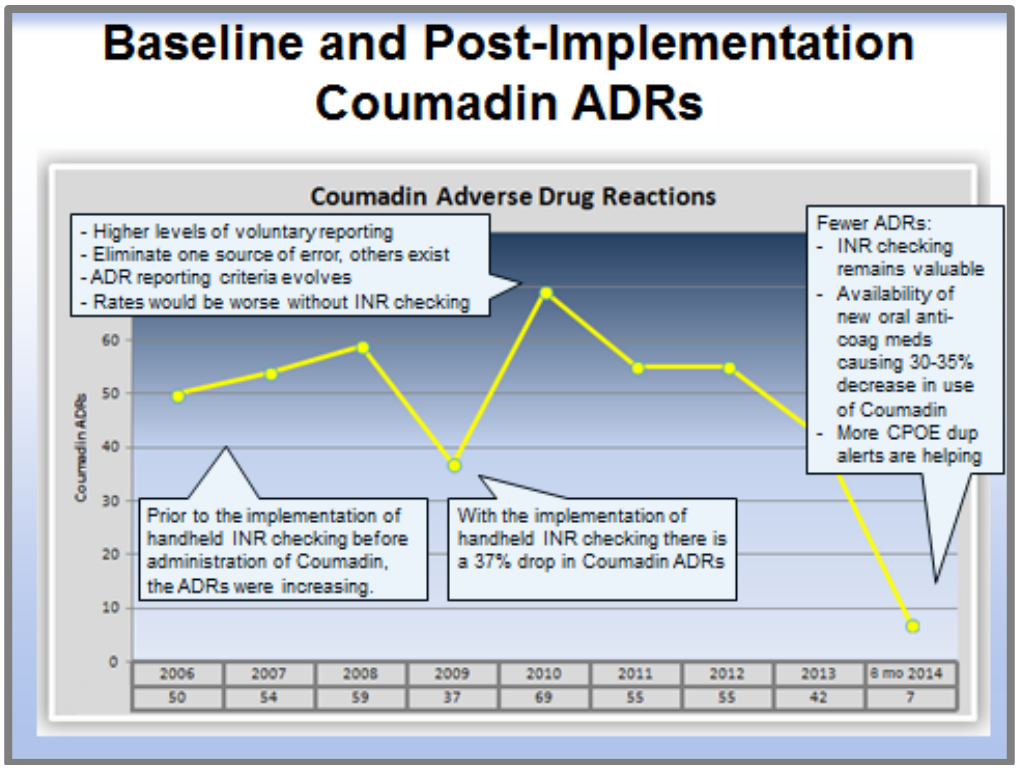
To ensure that the INR result is reviewed prior to Coumadin administration, the daily INR result is displayed on the nurse's hand-held device. The nurse must acknowledge review of the INR result at the bedside prior to administration. If it is within the predetermined goal range, Coumadin may be administered. For INR levels above the goal range, instructions are provided to the nurse to call the physician unless one of four displayed exceptions apply to the situation; again the nurse must acknowledge awareness of the situation. If there is no current INR result, the hand-held scanner does not permit the nurse to proceed. The nurse is instructed to obtain a STAT INR and to withhold administration until the INR result is obtained.

Value/Derived Outcomes:
The combination of the EHR clinical decision support and the 5 rights verification, delivered powerful patient safety outcomes and included value in three distinct areas for the hospital:

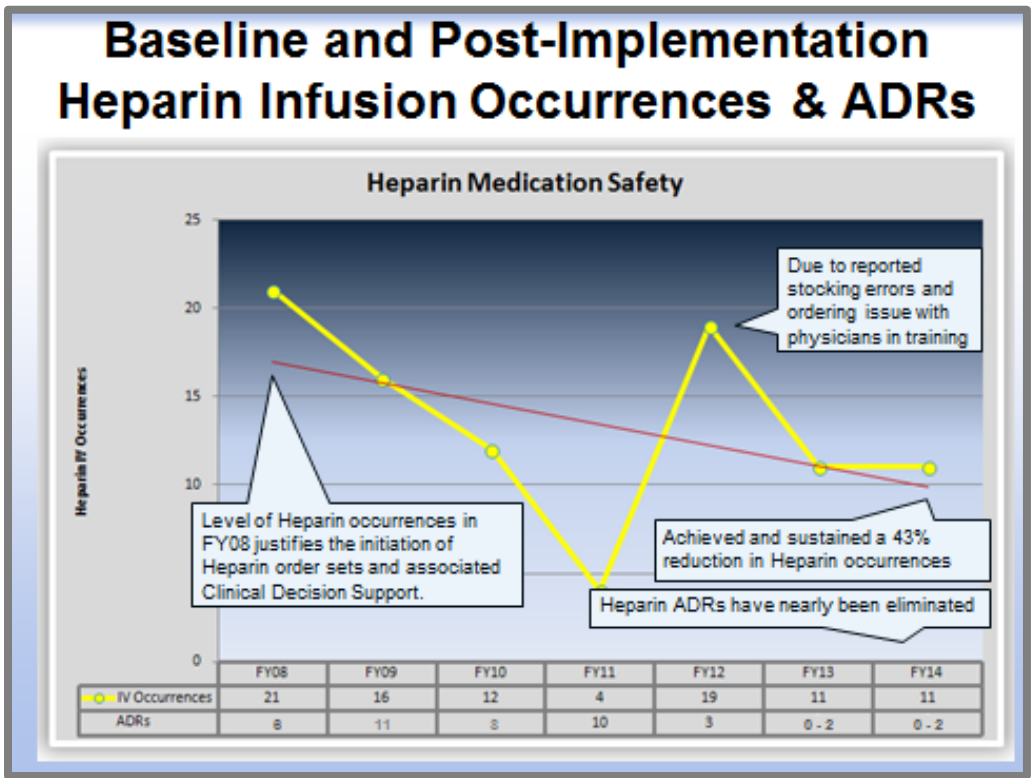
Patient Safety Value

- Since 2004, over 1,100 avoidable errors have been prevented, including three most serious preventable errors: Med Not Ordered for Patient, Med Discontinued by Physician, and Wrong Patient Scanned, a total of 4,168 avoidable medication administration errors were prevented.
- Occurrences of missed meds, and meds not given at the proper time, improved.
- High levels of adoption were achieved, thus sustaining patient safety gains every year.
- Nursing time savings were achieved through the auto-documentation feature, eliminating the task of manually charting to the eMAR.
- In the first twelve months following implementation, inpatient heparin infusion medication occurrences were reduced by 43%.
- Patients with a daily INR result reviewed prior to Coumadin administration rose from 93% in January 2008 to >99% from May 2009 through 2014.
- In the first twelve months following implementation, Coumadin adverse drug events (ADRs) decreased by 37%.





- The results of the enhanced clinical decision support for Heparin infusions is shown below. Through use of the initial Heparin order set, and maintenance order set including the dose adjustments based on the aPTT/INR results, Heparin infusion related ADRs have nearly been eliminated.



- The immunization workflow captured the lot number and manufacturer at the point of administration, and charted it in the EHR, virtually eliminating duplicate doses, and enabling electronic submission to state registries.
- The overall reduction in medication errors resulted in a significant reduction to length of stay as shown below where LOS savings are demonstrated for avoided ADEs:

Calculating the LOS Value of Avoided ADEs

- According to the HHS Office of Disease Prevention and Health Promotion National Action Plan for Adverse Drug Event Prevention, an inpatient ADE prolongs the hospital length of stay by 1.7 to 4.6 days.
- The table below shows the value associated with avoidance of ADEs

ADE	LOS Savings at 1.7 days per ADE	LOS Savings at 4.6 days per ADE
Using FY11 as baseline, 23 Heparin ADE have been avoided over the past 3 years	39.1	105.8
Using 2008 as baseline, 39 Coumadin ADE have been avoided from FY09 – 14	66.3	179.4
Using 2013 as baseline, 3 Dilaudid ADE have been avoided from Jan-Jun 2014	5.1	13.8
Total Days Avoided:	110.5	299
Dollar Value of Days Avoided:	$57,570	$155,779

Licensing

In 2006, the hospital granted a limited license of the system to Leading Information Technologies Institute, Inc. (LITI) of Tokyo, Japan. LITI was a leading provider of RFID technology in Japan and utilized the St. Clair technology on a pilot project to automate Japan's pharmaceutical supply chain. The hospital received $1M for the license.

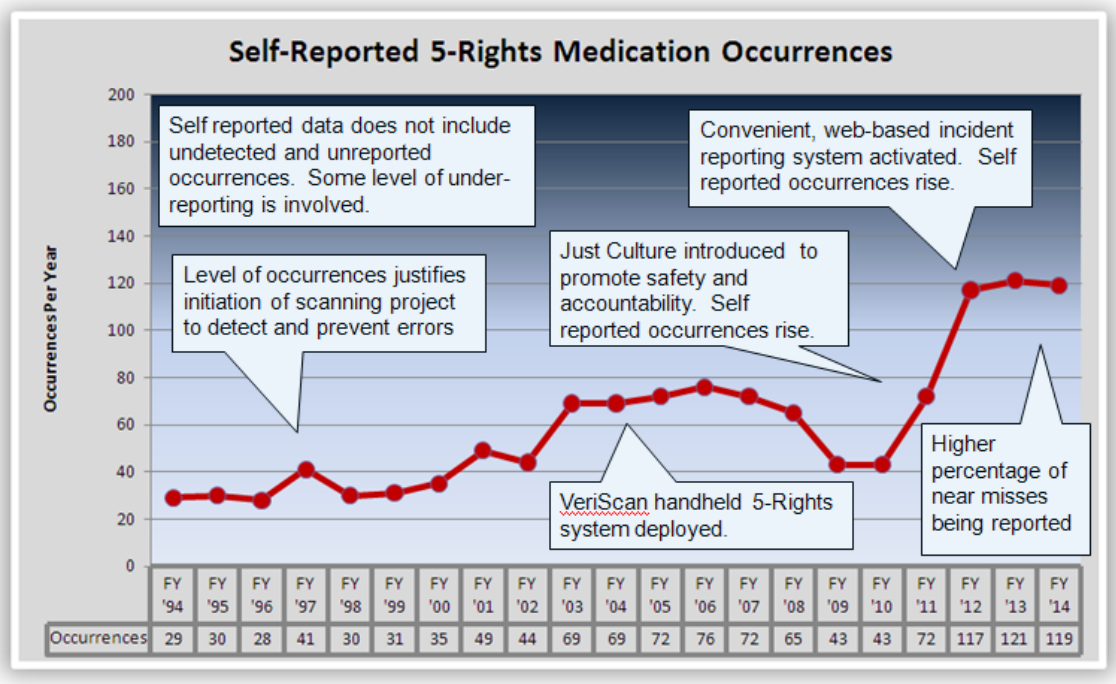
Sale of Technology

In 2008, in a lucrative multi-million dollar deal for the hospital, the technology was sold to a $6B global medical device maker. At present, St. Clair Hospital continues to serve as a development and test site for improvements to the system.

Lessons Learned:

- When EHR technology is used to provide granular tracking of a process, the frequency of error revealed can be eye opening.
- Anticipate that an initial spike in Medication errors will occur as implementation will expose under-reporting. This chart shows that the number of occurrences is closely

correlated to Culture, and to Ease of Reporting, and not necessarily aligned with ACTUAL occurrences.



- Improving medication safety requires both clinical decision support for ordering and 5 Rights verification for administration. The capabilities must leverage each other to maximize error reduction.
- A robust and reliable wireless network is essential to the success of mobile device deployment and nursing adoption of 5 rights verification at the bedside.
- Once the culture of an organization has changed and a new technology is embraced, it is possible to introduce changes to that system without impacting adoption. RFID scanning was necessary to drive adoption, but its eventual removal did not detract from adoption.
- The inadvertent inappropriate use of heparin protocols could only be stopped when the EHR includes logic to detect the error was embedded into the system. Without the hard stop in place, clinicians would continue to misuse initial protocols and maintenance protocols.
- With medication safety encompassing so many steps, it is difficult to work on all of them at the same time. The sequence of first addressing dispensing errors (through robotics or medication carts), then administration errors, and lastly, ordering errors, worked well. Although dispensing errors are outnumbered by administration errors, implementing dispensing technology as a first step also achieves the bar coding process that is necessary for successful 5 rights systems.
- Expecting clinicians to remember an extra step that must accompany a process, will virtually always fail. If lab tests need to be ordered when a medication is ordered, then it is best to have the EHR hard wired so that it occurs automatically. Likewise, if a nurse

must check a lab value at the bedside before medication administration, it is best to have it hard wired into the workflow on the handheld.

Financial Considerations:

I.T. Financial Considerations for Medication Safety Improvement Project

Type of Expense	Amount
I.T. analyst wage & benefit expense for 10,390 hours of systems work on preventing administration errors	$331,025
I.T. analyst wage & benefit expense for 524 hours of systems work on medication ordering errors	$20,282
Hardware: 120 handheld devices equipped with dual RFID / Barcode scanners; plus 2 RFID printers	$110,160
Hardware replacement: 120 ruggedized handhelds, including charging cradles, batteries, and annual maintenance cost	$177,893
Initial training (cost of nurse's and trainer's time)	$24,638
Average annual cost of IT training for new hires on use of handheld device. (Does not include cost of time that new hires spend with preceptors)	$560
Average annual cost of analyst time to maintain and upgrade the systems	$13,885
1-year cost of patient RFID wristbands	$20,800

The costs involved in achieving the quality and patient safety improvement in medication ordering and administration include labor, equipment and supplies, as shown in the table. The enhancements were made to the core EHR using its extensibility features and required no additional software licensing. The work hours dedicated to the project were performed by staff and no outside consulting costs were incurred.

The hard dollar ROI from licensing and sale are mentioned in the section above. Further determining the financial value of patient safety and error avoidance is a subjective process, however, a soft dollar ROI was calculated in 2005 after the system had been in use for a year. The equation below was used, and showed a soft ROI of $630k per year.

(Annual Admissions) x (PADE rate) x (PADE cost) = Savings

Where:

- Annual Admissions at St. Clair Hospital[1] = 15,646
- PADE (Preventable Adverse Drug Events) Rate[2] = 0.63 per 100 admissions
- Cost of PADE[3] = $6,400

Resulting in approximately $630k in annual savings[4]

[1] Fiscal Year Ended June 30, 2005

[2] Journal of American Medical Association, Vol. 277, No. 4 (Note: rates ranged from 0.63 to 2.43 per 100 admissions).

[3] Healthcare Quarterly, Vol. 8, No.3, 2005, page 6

[4] In 2004 the FDA published figures showing PADE rate of 2.4 to 6.5 per 100 admissions, and $2,257 ADE cost