CASE STUDY

# Clinical and financial effects of smart pump–electronic medical record interoperability at a hospital in a regional health system

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**Purpose.** The pharmacist-led implementation of a smart pump–electronic medical record (EMR) interoperability program at a hospital within a regional health system is described.

**Summary.** Smart pump–EMR interoperability involves a wireless, bidirectional connection by which infusion information transmitted by the EMR prepopulates infusion devices, reducing keystokes and opportunities for manual programming errors. The smart pumps transmit time-stamped infusion data to the EMR for nurse documentation. Use of interoperability technology forces the use of dose-error reduction software so that 100% of prepopulated infusions and dosage adjustments are protected. To improve i.v. medication safety and documentation at a 286-bed hospital within an 8-hospital health system, pharmacists led an initiative to implement smart pump–EMR interoperability as a first step toward systemwide implementation. The hospital's smart pump–EMR interoperability initiative resulted in patient safety and revenue-generation gains in the first 8 months after implementation. The mean number of keystrokes needed to program an infusion was reduced from 15 to 2 (an 86% decrease). Pump alerts, alert overrides, and reprogrammed or cancelled infusions were decreased. In addition, the program improved outpatient charge capture, resulting in $370,000 in incremental revenue.

**Conclusion.** A pharmacist-led implementation of smart pump–EMR interoperability led to measurable, data-based improvements in i.v. medication safety and improved accuracy, timeliness, and efficiency of i.v. infusion documentation. Revenue was increased due to improved charge capture for outpatient i.v. infusions.

**Keywords:** adverse drug event, electronic medical record, interoperability, i.v. infusion medication safety, pharmacist-led implementation, smart pumps

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Infusion therapy plays an essential role in advanced medical care. However, among all types of drugs involved in medication errors, i.v. medications pose particular risks because of their greater complexity and the multiple steps required in their administration.[1] Preparation and administration of a single dose of an i.v. medication could result in up to 21 separate errors,[2] and i.v. medications are associated with 54% of potential adverse drug events (ADEs).[3] Of the most serious and life-threatening potential ADEs, 61% are associated with i.v. medications (Bates DW, Brigham & Women's Hospital, Boston, MA, personal communication, 2001 Oct).

Compared with medications delivered via other routes, i.v. medications are twice as likely to be involved in errors that cause patient harm.[4] Even a single wrong keystroke in programming an i.v. medication pump can

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result in patient harm; for example, a missing decimal point or a double key press can result in a 10- or 11-fold overdose. Similarly, a 24-hour dose can be inadvertently programmed to be delivered in just 1 hour.[3]

The use of smart i.v. infusion pumps with dose-error reduction software (DERS) has been proven to help avert potentially serious i.v. medication errors.[5-7] Nonetheless, a major study at an academic medical center found that even though smart pumps were in use, 67% of the 426 in-process infusions evaluated involved 1 or more discrepancies, including potentially fatal errors.[8] Of these discrepancies, 119 (28%) could have been prevented through the interoperability of smart pumps and the electronic medical record (EMR) system. The ECRI Institute reported in 2013 that smart pump–EMR interoperability, which makes it possible for infusion pump programming to be automatically checked against medication orders, could prevent 75% of the pump-related medication safety issues analyzed from its database.[9]

## KEY POINTS

- Smart pump–EMR interoperability improves medication safety by reducing manual programming errors.
- Smart pump–EMR interoperability improves documentation of accurate infusion start and stop time to decrease lost administration charges.
- Successful implementation of smart pump–EMR interoperability requires multidisciplinary team collaboration led by pharmacy leaders.

## Background

The leadership of an 8-hospital regional health system commissioned an overall quality report for the entire system. One of the report's key findings indicated that in just 1 month, nurses manually programmed 272,692 smart-pump infusions using 4,090,380 manual keystrokes, which equated to more than 4 million opportunities for human errors in medication administration every month.

A separate analysis at 1 of the health system's 8 hospitals found that the hospital was failing to capture an average of 11.9% of billable outpatient infusion charges annually, which equated to roughly $980,000 in lost revenue and accounted for 21% of the health system's overall annual missed-reimbursement opportunity.

Pharmacy leaders at that hospital then began to explore the possibility of implementing smart pump–EMR interoperability to decrease opportunities for error by reducing the number of clinician keystrokes needed to program an infusion. The opportunity to simultaneously improve charge capture and increase reimbursements also helped convince administrators to support implementation. Our aims were to improve i.v. infusion medication safety; improve the accuracy, timeliness, and efficiency of i.v. medication documentation; free up pharmacist and nurse time for direct patient care; and increase revenue in outpatient areas by improving charge capture and reimbursement for i.v. medications.

In September 2013, we entered into an early-adopter partner site agreement with our smart-pump and EMR vendors to implement bidirectional communication (interoperability) between the 2 systems.

## Analysis and resolution

**Engaging key stakeholders and communicating program goals.** We hosted an interprofessional kickoff meeting in October 2013 and formed systemwide and local steering committees comprising pharmacy and nursing staff members; personnel involved in quality assurance, clinical informatics, information technology (IT), clinical engineering, project management, and education; and EMR and infusion-pump vendor representatives. The hospital–vendor teams developed a detailed plan to manage every step of the pilot and systemwide implementations of the integrated system. As a first step in this process, we focused on educating steering committee members about the potential benefits of interoperability. This step was critical to cementing the buy-in and support of all key stakeholders needed to implement the program.

Promoting early awareness and adoption was an important strategy for success at each site. Systemwide pharmacy and nursing informatics committees were developed to share best practices and brainstorm proposed improvements. Initial steps included workflow analyses, especially for practices identified to involve multiple workflows to achieve the same endpoint, depending on the clinical area or particular nurse involved. For example, workflows for i.v. fluid bolus injections, i.v. intermittent infusion flush injections, bolus infusions from i.v. bags, and smart-pump drug library revisions were discussed and finalized.

**Rationale for implementation.** *Potential to improve medication safety.* Successful implementation of interoperability creates bidirectional communication between smart pumps and the EMR so that the prescriber-ordered, pharmacist-reviewed infusion information (medication name, dose, rate, volume to be infused, total volume, and patient weight) is sent wirelessly from the EMR to the infusion device. Prepopulating a smart pump with the ordered infusion parameters sent directly from the EMR (instead of through manual keystroke programming) reduces opportunities for errors and improves medication safety. Prepopulating a smart pump using interoperability also forces the use of the DERS embedded in the smart pump so that 100% of prepopulated infusions and any subsequent dose, rate, or volume adjustments are protected by the pump's safety software.

In addition to prepopulating a smart pump with infusion data, the system sends time-stamped infusion data from the pump (dose, rate, and volume infused) back to the EMR in near real time for validation and documentation by the nurse. Any subsequent changes in infusion parameters, such as dose adjustments to achieve a desired physiological response, are also automatically sent to the EMR. After verifying the infusion data, the information becomes part of the legal EMR. The accurate, timely infusion data can then be analyzed to identify opportunities to improve care, reduce variability, and eliminate waste. Online infusion data logs and reporting provide information that can be used by pharmacists and nurse informaticists to help identify workflows, reinforce compliance, implement practice and process improvements, and track programming errors and instances in which the DERS catches an error that otherwise could have resulted in patient harm.

*Proposed effects on nurses' time and environment.* Interoperability frees nurses from the burden of manual documentation yet keeps them involved in the process, as they must use their clinical expertise to verify the infusion information before committing it to the patient record. It has been reported that nurses spend 4 hours per shift documenting and completing forms.[10] We conjectured that smart pump–EMR integration would reduce the time spent in documenting use of i.v. medications. We estimated that reducing documentation time by just 5% would free up 40 minutes per shift, or 1.2 hours per day. Given that the health system is staffed by an average of 1,200 nurses each day, we calculated that a 5% savings in staff time would represent $6,720 in cost savings on a daily basis, or $2,452,800 annually—time and expenditure that could be repurposed for other activities such as direct patient care.

In addition to identifying opportunities for nursing workflow efficiencies, we also identified early on that room setup would likely play a key role in adoption and success. We hypothesized that if the configuration of a room required the nurse to walk back and forth from the computer to the pump (especially if this required movement around a bed), a longer setup process would be required, potentially leading to frustration among nursing staff. These considerations are often missed in testing, when all programming is typically done at a desk with the pump and computer in close proximity. Timely discussions regarding the location of computers in patient rooms (ideally, using work stations on wheels when possible) and types of scanners (i.e., tethered versus wireless) are key to nurse buy-in and longer-term compliance. If equipment must be purchased, attention to these details is a key part of the discussion and final decisions.

*Potential effects on reimbursement for i.v. medications.* So that appropriate reimbursement can be obtained, billing rules require personnel in hospital outpatient and observation areas to document the actual administration time (i.e., both start and stop times) for all outpatient i.v. medication services rendered. In 2013, an evaluation of outpatient infusion claims at all 8 hospitals in the health system determined a net revenue loss amounting to over $4 million. The majority of these lost charges were due to a lack of sufficient documentation to support the billed charges or missing documentation, specifically stop times, in the medication administration record. Over the years, various educational campaigns were conducted in an attempt to improve outpatient i.v. medication documentation throughout the health system. While small gains were achieved, they were not sustained, and significant opportunities remained. The pharmacists who led the smart pump–EMR interoperability program hypothesized to the steering committee that interoperability would enhance documentation and further standardize and improve best practices with regard to recording the data necessary for improved reimbursement.

**Planning and implementation.** The team opted to implement interoperability for both large-volume infusion pumps and syringe pumps; at the time of project planning, the latter were used extensively in the neonatal intensive care unit (NICU) and the pediatric intensive care unit, where programming of infusion rates and doses required a level of precision not available in the health system's large-volume pumps**.**

A high level of standardization is required in order for an interoperability initiative to be successful. To achieve this, a crosswalk was created to identify variances in medication data between the EMR and the drug library. We then updated the infusion library with dosing parameters and medication aliases (specific identifiers attached to all drug names) consistent with those used in the EMR. We also updated medication records in the EMR to include all the required infusion data fields for each infusion type, such as fields specifying the infusion rate and duration. We implemented a double check to ensure that all aliases populated the correct drug library and corresponded to those in the EMR; this sort of profile consolidation streamlines nursing workflow, especially when there are patient transfers between units, and ensures that a drug library build for a weight-based medication also has a corresponding non–weight-based entry if dose rounding is allowed.

Observation of nursing practices on patient care units helped the implementation team to ensure that the system would support all of the various medication administration scenarios encountered in patient care, from small-volume syringe infusions to large-volume infusions, as well as rapid dosing adjustments based on a patient's condition. The team also made necessary changes to streamline workflow, such as reconfiguring rooms so that infusion pumps and EMR computers could be accessed at the same

time for the most accurate infusion documentation. In some instances, the environment of care posed unexpected challenges. For example, if a lead-shielded, portable X-ray machine was positioned between the smart pump and the wireless access point, infusion parameters could not be transmitted from the EMR to the smart pump. Each patient care area was assessed to help ensure that interoperability would be successful for every infusion.

**Collaboration.** Pharmacists worked extensively with key stakeholders to align the smart-pump data sets and EMR formulary and to ensure that all orders would work with the prepopulation function. Video and "e-learning" materials helped nurses learn how to use the new system. Hands-on experience with an actual pump and the EMR training system was used to help train clinical educators, nursing supervisors, and super users on individual units. Clinical informaticists helped other technical staff better understand nursing staff workflows, practices, and needs.

Finally, collaboration with clinical engineering and technical infrastructure teams was a key early step. Importantly, we engaged clinical engineering personnel to understand the new relationship between the pumps and the EMR so that they could understand how pump maintenance might affect connectivity. We also reviewed with clinical engineers the importance of maintaining barcodes for each pump channel. We also conducted a full assessment of each site's wireless infrastructure to identify potential connectivity issues in advance of the "go-live" date.

**Impact assessment.** Seven months after the program's kickoff, smart pump–EMR interoperability was fully implemented on all care units, excluding the NICU and procedural areas such as the operating room and cardiac catheterization laboratory.

*Medication safety improvements.* Prepopulation of infusion parameters reduced manual keystrokes by 86%, because a nurse no longer had to key in the parameters (e.g., drug, dose, rate, concentration, volume). At the time, we calculated that similar results at all 8 hospitals would eliminate almost 3.5 million keystrokes per month, resulting in 3.5 million fewer opportunities for error every month. At the end of the first week at the pilot-testing site, more than 805 infusions had been completed successfully using interoperability technology, and 185,000 status messages had been successfully sent and received. Additionally, clinicians were able to review data in the EMR and correlate medication dosing to a patient's vital signs, knowing the documentation was timely and accurate.

Compliance in using interoperability technology was tracked weekly and, with regard to prepopulating infusion pumps with infusion parameters from the EMR, averaged 70–80% in the first 7 months. This was exceptional given that nursing personnel can always opt out of using interoperability functions and manually program pumps. Ongoing education of end users and changes to the pump and EMR drug libraries have been performed on the basis of weekly compliance reports, resulting in compliance averaging 90% or more in the most engaged units.

Looking at all infusions, both those programmed using interoperability technology and those programmed manually, the monthly mean percentage of infusions administered with DERS protection increased from 91.8% to 94.4%. The rate of appropriate entry of patient identification information by pump users increased from 35.5% to 81.0% as a result of that information being part of the order parameters sent to pumps. Previously, clinicians had to remember to manually input the patient identification number on the device, which we hypothesized had accounted for the low compliance. The mean number of total monthly pump alerts decreased from 1,845 to 1,447 (a 22% reduction), and the mean number of monthly alert overrides decreased from 1,560 to 1,240 per month (a 20.5% decline). The mean monthly number of infusions that were reprogrammed in response to a DERS alert decreased from 119 to 96 (a 19% drop), and the mean number of canceled infusions in response to a DERS alert decreased from 166 to 111 per month (a 33% decline). These decreases were due to interoperability technology (i.e., prepopulation of infusion parameters) leading to fewer manual errors for the DERS to catch. Manual programming was still used to make the changes needed to adjust a drug dosage to the patient's response. After implementation, self-reported annual safety events related to infusion pump programming were reduced from 3 to 1. In the 1 self-reported safety event that occurred after implementation, interoperability functions were not used; if they had been, the event would have likely been prevented.

*Financial performance improvements.* Implementation of smart pump–EMR interoperability provided accurate infusion start and stop times in the patient record. This reduced mean lost charges for outpatient infusions from 11.9% to 7.4% and lost revenue from $980,000 to $610,000 (a decrease of approximately 40%), which represented $370,000 in incremental revenue for the pilot-testing site.

*Stakeholder satisfaction.* The nursing staff's reaction to the new processes was positive. Clinicians reported that they were more satisfied knowing that they could confidently manage i.v. medications with greater safety.

*Significance to the health system.* The pharmacy-led teams' successful implementation of smart pump–EMR interoperability and the positive results it yielded provided the necessary evidence for the health system to proceed with systemwide implementation at the health system's other 7 hospitals. As these implementations progressed, hospital pharmacists provided invaluable leadership in helping to guide other facilities to successful

implementations. Compliance-report data were shared across the system to help leverage peer accountability across like units and different sites.

The next step in enhancing the financial savings associated with the interoperability program is to implement the pump vendor's charge capture and "infusion viewer" software to support coders and billers. The new charge capture software will provide a comprehensive, patient-specific infusion report that summarizes infusion start and stop times and also includes the total duration of every infusion minus time required for pauses, stops, "keep vein open" infusions, and alarms. The report can be scanned and attached to the patient's record as a PDF file or uploaded as a .csv file to the EMR to further support auditing. The tool's Web-based infusion viewer dashboard will also allow pharmacy personnel to view the status of every infusion in near real time in order to better plan for preparation and distribution of i.v. medications and avoid waste.

## Discussion

The use of advanced medication technologies is an increasingly important part of health-system pharmacy practice. The earliest adopters of highly complex technologies are often major medical centers. The innovative program described here highlighted pharmacists' leading role in helping achieve smart pump–EMR interoperability at a hospital within a regional health system; it was the first hospitalwide implementation of interoperability technology carried out with the hospital's technology vendor partners. As discussed above, the program met all of its medication safety and cost savings objectives.

While major medical centers are often in the best position to afford higher-priced technologies, regional and local hospitals and health systems may struggle to acquire technology solutions they need and want. Cost savings achieved by avoiding ADEs are often considered "soft dollars" and are difficult to quantify. The improved, measurable i.v. charge capture that interoperability technology delivers can help gain administrative approval for implementation. The program described in this article also demonstrated that "financial stewardship" is an important part of pharmacy practice in today's high-tech world.

In the years ahead, the interoperability of smart medical devices and IT systems will undoubtedly become even more important, as the ability to automatically capture and manage patient data will play an increasing role in improving patient safety, clinical outcomes, staff productivity, and financial performance.[11]

## Conclusion

A pharmacist-led implementation of smart pump–EMR interoperability led to measurable, data-based improvements in i.v. medication safety and improved accuracy, timeliness, and efficiency of i.v. infusion documentation. Revenue was increased due to improved charge capture for outpatient i.v. infusions.

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## Disclosures

Dr. Biltoft and Dr. Finneman served as CareFusion Intelligent Hospital Pavilion Leadership Theatre panelists. They have declared no other potential conflicts of interest.

## Additional information

The project described in this article was described in detail in a poster presentation at the ASHP 2015 Summer Meetings, Denver, CO, June 6–10, 2015.

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