Reducing Hospital Lengths of Stay with EMRs and Other Information Technologies
Global eHealth Executive Council

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Abstract

Electronic medical record (EMR) systems and other information technologies have the ability to impact hospital lengths of stay in numerous ways. Computerized provider order entry (CPOE; systems that combine e-prescribing and order communications) and its associated decision support interventions are the most powerful EMR-related tools for reducing hospital length of stay (LOS), but each hospital is somewhat unique in its LOS-related issues and potential IT-related solutions.

LOS Reduction Theory

Average lengths of stay (ALOS) for all hospitals in the United States are unchanged since the year 2000, after falling dramatically during the previous decade (see Figure 1 below for community hospital data).

Figure 1: US Community Hospital\(^1\) Average Lengths of Stay

![Figure 1: US Community Hospital\(^1\) Average Lengths of Stay](image)


Because of this trend, many hospital leaders assume that we are at or near the limits of acute care LOS reductions, and that there will be little further progress. However, substantial variation in risk-adjusted lengths of stay across geographic areas (see Figure 2 below) indicates that there may still be opportunities to reduce LOS. Experts estimate that the percentage of “avoidable hospital days” ranges from 22% in Oregon to 47% in New York.\(^2\)

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1) Community hospitals are designated as all nonfederal, short-term general, and special hospitals, including special children’s hospitals, whose facilities and services are available to the public. If all US hospitals are included, ALOS is unchanged since 2000.

Figure 2: Geographic Variation in US Hospital ALOS

Other studies show that shorter hospital stays are not necessarily associated with higher rates of patient readmission or mortality. In fact, shortening hospital LOS can reduce the risk of nosocomial infections and other adverse events. As we will show in this report, many opportunities still exist to reduce LOS by increasing timeliness and efficiency without increasing patient health or safety risks.

While some US hospitals still do substantial charge-based or per-diem business, our modelling shows that most will save money by reducing lengths of stay, and that the impact will only grow as per-case or population-based reimbursement becomes even more common.

EMR Impact on Hospital LOS

Reductions in hospital lengths of stay are one of the most commonly reported hospital EMR benefits. The overall LOS reductions described in EMR benefit studies range from 5% to 15%, with greater reductions observed in subpopulations. However, the research on EMR-related LOS reduction is not as clear cut as that for some other benefits, such as medication error and adverse drug event reduction, reduction in unnecessary lab testing, reduction in drug utilisation and costs, etc. While these other EMR benefits have been the subject of numerous controlled studies, the causes and

5) Davies, Nicholas E. “Maimonides Medical Center: Maimonides Medical Center makes a quantum leap,” Symposium Proceedings 2002. HIMSS Chicago, IL.
6) Mekhjian HS., et al., Immediate benefits realized following implementation of physician order entry at an academic medical center, J Am Med Inform Assoc, 2002;13:529–539.
degree of reported LOS reductions are often obscured by the concurrent use of other LOS reduction strategies beyond the EMR (e.g., process redesign, pre-admission testing), lack of risk adjustment, and timing issues (e.g., seasonality, weekends).

An EMR or other information technology does not affect every factor that contributes to LOS, but it does have a potentially substantial impact on many of them. In some cases this impact is “automatic,” or directly associated with the presence of certain EMR capabilities. For example, use of CPOE can eliminate errors and delays associated with order transcription and lead to care being delivered in a safer and more timely manner (although poor CPOE design and execution can result in other types of errors).

However, in most cases the EMR’s impact on LOS also requires innovation, or changes in processes and behaviour. For example, the use of evidence-based order sets, practice guidelines, and clinical pathways has been shown to reduce hospital lengths of stay.\textsuperscript{10,11,12,13,14} To the degree that an EMR makes it easier to use these tools, and more likely that they will be used, it should reduce LOS; however, designing effective electronic order sets, guidelines, and pathways, and convincing doctors and nurses to use them can take months or years of effort.

Because many LOS-reducing capabilities are unique to the EMR (e.g., electronic order management, CPOE-driven clinical decision support, single-patient record that is always available to multiple users), a hospital with an advanced EMR, used in an innovative manner over time, should have an ALOS that is lower than a hospital without these capabilities and practices, although the research to prove this theory has not been done.

In addition to EMRs, there are several other complimentary technologies that can help reduce hospital lengths of stay. These include patient tracking systems, real-time locationing systems (RTLS), process automation software, unified communications systems, and mobile communication devices. These solutions can be used individually, or in conjunction with an EMR; in most cases one or more of these solutions integrated with an EMR will yield superior results.

We interviewed and/or reviewed documents from individual hospitals or multi-hospital providers, comprising a total of 47 individual hospital facilities that have previously published or publicly claimed EMR-related LOS reductions. We asked their IT leaders and staff, clinicians, and finance/operations executives whether they specifically pursued LOS reductions with their EMR, and if so, how they went about this pursuit, how they measured the changes in LOS, what barriers they faced and overcame to achieve LOS reductions, etc.

We hoped to better understand the impact of the EMR and other IT on specific sub-elements of LOS, as described above, and to identify the most cost-effective, IT-related strategies and applications for reducing LOS.

Selected Case Studies

**Children’s Medical Center**

Children’s Medical Center of Dallas, Texas, cut emergency department (ED) LOS by 30% and reduced median LOS for bronchiolitis from 2.4 days to 1.95 days (19%) after


going live on its EMR. The primary mechanisms credited by Children’s for this reduction were the use of clinical guidelines, pathways, and the EMR’s clinical decision support capabilities. Children’s also substantially reduced medication delivery time by integrating their EMR and on-unit medication cabinets.

**Geisinger Medical Center** in Pennsylvania reduced average hospital LOS for coronary artery bypass graft (CABG) cases by 16% through its Proven Care™ programme, which is designed to ensure that evidence-based care is reliably delivered to every patient. Through extensive research, Geisinger identified 40 critical steps that greatly improve the chances of a successful CABG operation and recovery—these include screenings, interventions, medications, and monitoring. Geisinger’s EMR helps ensure that these 40 critical steps are followed for every patient, through the use of checklists, default documentation templates, health maintenance gap reminders, and automated order sets; the EMR identifies gaps in care so they can be completed in a timely manner (e.g., before surgery).

Geisinger’s pre- and post-implementation analysis showed that 100% of Proven Care™ patients received all 40 care elements included in the bundle, compared with just 59% of those in the conventional care group. Average total hospital LOS was 5.3 days in the Proven Care™ group, compared with 6.3 days in the conventional care group, and hospital readmission rates were substantially lower for the Proven Care™ patients.

**Maimonides Medical Center** in New York City was one of the earliest providers to report reduced lengths of stay associated with EMR use. In 2002 Maimonides reported that their average hospital LOS had fallen from 7.26 days in 1995, prior to EMR rollout, to 5.05 days in 2001 (a 30% reduction), which was 1 full day less than the New York City average. Maimonides credited the following EMR capabilities for part of their LOS reduction: electronic availability of legible documentation; electronic ordering and results review that resulted in fast turnarounds (e.g., a 68% reduction in medication processing time), reduced delays and speeded-up patient care; and standardised electronic order sets that helped reduce practice variation and unnecessary care. While acknowledging the power of the EMR to help drive reduced LOS, Maimonides credited the “automated” effects of the EMR with only a fraction of the total reduction, noting that major workflow reengineering was also required for many of their LOS reductions.

**Sentara Healthcare** in Norfolk, Virginia, reduced their weighted average LOS across all hospital facilities from 6.7 in 2006 (pre-EMR implementation) to 5.7 in 2011 (post-EMR), a 14% reduction. Although the pre- and post-metrics are not risk-adjusted, their overall case mix index did not change significantly during this time period. Sentara credits three major elements with their LOS reduction: reduction in adverse drug events, an increase in the “pace of care” (fewer delays), and improvements in the reliable delivery of evidence-based care. Sentara estimates that the combination of ALOS reductions and adverse drug event reductions saved $8.7 million in 2010. Sentara estimated they prevented 117,000 potential medication errors annually as a result of EMR alerting (measured when an alert resulted in a change in nursing practice). As Garrett Blair and Ken Rice, Process Improvement Experts at Sentara Healthcare put it “Two to three percent of these could have caused substantial patient harm and extended LOS”. Improvements in the pace of care included reduction in charting delays associated with paper charts, a two-hour reduction in order communication time due to the use of CPOE, more rapid communication of patient information between clinicians, a 71% reduction in medication administration time, and reduction of ED-to-inpatient-bed transfer times and unit-to-unit transfer times of 25% to
40%. Improvements in the reliability of care delivery resulted from the use of standardised electronic order sets and best practice protocols built into the EMR, and various clinical decision support capabilities.

Sentara delayed CPOE go live for six months for their first hospital implementation, but realised CPOE implementation should be simultaneous with all subsequent hospital implementations as its benefits became obvious. CPOE use now stands at 85% to 87% of orders. Sentara is still working on improving its order sets, and still trying to improve and automate its medication reconciliation process.

Hospital Marina Salud

*Hospital Marina Salud* in Denia, Spain, is a new, all-electronic hospital that opened in 2010. While it had no baseline LOS data from before 2010, Marina Salud has seen dramatic hospital LOS reductions from an average of 5.9 days in 2010 to 5.2 days (12%) in 2013. Both before and after figures are substantially lower than local benchmarks. Some of the LOS reduction since 2010 resulted from completing patient prep work prior to rather than after hospital admission, but hospital leaders also credit the EMR’s impact on reducing common process delays. LOS reductions after hospital opening and EMR go-live point out the role of ongoing optimisation (innovation) as hospital clinicians and IT staff learn to use the EMR’s capabilities over time.

Notable LOS-reducing EMR capabilities at Marina Salud include the ability for providers to access the EMR from home or other remote locations, eliminating the need to wait until their next hospital visit to document or consult; automation of the discharge process, including preparation of the discharge summary report, allowing morning rather than afternoon discharges; the use of standardised electronic nursing care plans; the use of automated risk assessments to modify expectations and care plans; and automation of the medication management process from order to administration, reducing the time to medication administration. Dr. Rafael Sala, Medical Director, said, “We feel that the EMR has had an impact on hospital lengths of stay, but it’s not easy to measure that link, in all cases.”

It is worth noting again that ALOS in US hospitals are little changed since the year 2000, despite the overall increase in the use of EMRs. Even so, the hospitals with EMR-based innovation efforts we profiled above saw dramatic LOS reductions. US hospitals in general had the same incentives to reduce LOS as those whose cases we reviewed, and presumably were trying to reduce LOS in response to those incentives, leading to the conclusion that an EMR, properly used, results in a changed capacity for LOS reduction.

Lessons Learned

What can we learn from the literature and our case studies about specific tips, tricks, and the most powerful interventions for reducing LOS with information technology?

The factors that increase hospital LOS and which are amenable to improvement using an EMR and other information technologies fall into three primary groups:

Process Delays

In care delivery, patient movement, communication, etc. These delays slow a patient’s healing process and/or discharge from the hospital. Major examples of processes in which delays occur include:

- Order entry or communication
- Drug administration
- Result viewing/review
• Locating equipment and supplies
• Documentation
• Transfer order writing
• Patient transfer between units
• Discharge order writing
• Patient discharge

Based on our research, the most cost-effective EMR-related impacts on process delays include:

• **CPOE.** Ubiquitous CPOE can help greatly reduce order communication and execution times. Texas Health Resources reported that CPOE use cut average time from order writing to computer input for non-stat orders from 118 minutes to zero. Sentara reported that the average time from drug order writing to when the order was available to act on fell from 59 minutes to 4.5 minutes, and average time from order writing to medication administration (for urgent orders) fell from 132 minutes to 38 minutes. MemorialCare’s California hospitals report that CPOE has helped them cut turnaround times for stat medication orders from 41 to 6 minutes, with fewer delays related to order clarification. And Maimonides Medical Center reported a 68% reduction in medication processing time.

• **Integration of outpatient, ED, and inpatient data in the EMR,** presentation of these data in simple, easy-to-use formats, and creation of standardised workflows to help clinicians use these data. Examples include tracking boards and automated discharge planning tools. Geisinger Medical Center uses special discharge flow sheets to structure discussions in multi-disciplinary team meetings. When a patient is ready for discharge, a clinician clicks a button in the EMR and automated notifications are sent to everyone with a role in patient discharge. Each of those individuals can also see a summary of which discharge tasks have been completed. Electronic results review is the simplest example of this concept: the Denver Health and Hospital Authority reported a 54% reduction in time between specimen collection and care delivery with laboratory results availability online, and a 62% reduction in time between exam and care delivery with radiology results available online. In another example, Bronx-Lebanon Medical Center in New York City created a “length of stay clock,” showing the time the patient was admitted, the expected ALOS for that particular disease and its severity of illness, and how much hospital time the patient had left. The clock helped doctors figure out how much care they could provide during hospitalisation and how much could be shifted to the outpatient setting. This approach resulted in a 1.8 day reduction in length of stay in less than a year.

• **Use of the EMR,** combined with other technologies such as unified communications systems, communication “badges” and other mobile devices, to make it easier and faster for doctors, nurses, and other clinicians to communicate with each other.

• **ED tracking and patient management systems.** Integrated EMR vendors have improved their tracking and patient management functionality compared to best-of-breed ED information system vendors. These systems use large tracking boards to show clinicians where each patient is in the ED, what tests and interventions have been ordered and received, which staff members have been assigned to that patient, and what the patient needs next. Many hospital EDs have reported dramatic LOS reductions after implementing these capabilities.

• **Two emerging technologies, RTLS and process mapping and automation software,** have great promise for the future, despite the current lack of real-world examples of LOS reductions.
  – The use of RTLS in combination with an EMR to ensure that equipment is where it needs to be before a patient arrives (e.g., postop recovery), stocking needs are anticipated earlier, that shortages are reduced or eliminated, staff are informed of the progress of patients and are better able to plan their work, etc., should reduce process delays.
The use of process mapping and automation software (e.g., Tibco) to automate transitions from one process step to the next and ensure more reliable process performance also has great potential to reduce process delays. Process automation software typically includes a *business rules engine* which defines what should happen in a process and a *workflow engine* which can "...drive the execution of...transactions through the native services of the EMR—such as its messaging system, work list functions, order management system, clinical decision support (CDS) system, and rules engine."¹⁵

**Errors and Adverse Events**

Some medical errors and adverse events harm patients and/or require repeating an action, leading to delays. If a patient is harmed, it may take additional time in the hospital to repair that harm, extending LOS. Common examples include:

- Medication errors (e.g., wrong drug, wrong dose)
- Adverse drug events (ADE)
- Preventable nosocomial infections (e.g., sepsis)
- Deep venous thrombosis (DVT) or pulmonary embolus (PE)
- Ventilator-associated pneumonias (VAP)
- Hospital-acquired pressure ulcers (HAPU)

Based on our research, the most cost-effective EMR-related interventions to reduce medical errors and adverse events include:

- Ubiquitous CPOE can help reduce order communication and execution times, including reducing drug delivery times from several hours to around half an hour and speeding critical lab test completion. CPOE use can virtually eliminate order transcription errors, preventing an estimated 150 adverse drug events annually in a typical 300-bed hospital, and preventing other errors related to lab testing, therapy, etc. It is also the delivery mechanism for many clinical decision support interventions, which can help improve patient safety.

- Sepsis surveillance uses EMR data to identify patients at risk for sepsis and trigger timely interventions to prevent or ameliorate sepsis. The UC Davis Health System in Sacramento, California, used EMR sepsis surveillance to save 54 lives in 2011; mortality was reduced by 25% over the 2009 baseline.

- Decision support integrated with care guidelines or protocols help ensure that best practices are followed to prevent adverse events. An example is Vanderbilt University Medical Center’s VAP surveillance software,¹⁶ which helped prevent 108 VAPs and 16 deaths in fiscal year (FY) 2009, saving $2.5 – $4.3 million.

- Drug dosing CDS helps prevent overdoses, especially in children’s hospitals and for specific patient populations; however, in most adult hospitals its impact is probably not substantial enough to qualify as a “most cost-effective” intervention.

**Sub-optimal Care Delivery**

It is difficult to reliably deliver the very best care in the most timely manner possible. Typically, some elements of care are provided in a variable, delayed, non-evidence-based, or otherwise less effective manner. These variations from the ideal may impact patient recovery times and increase LOS.

Based on our research, the most cost-effective ways to improve the effectiveness of care delivery are the following:

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• Evidence-based and/or standardised electronic order sets for high-volume conditions with high LOS variation between doctors, and some evidence supporting standardised care.
• Decision support integrated with care guidelines or protocols to ensure that the best care is provided to all patients in a reliable manner. Geisinger’s Proven Care™ programmes (CABG program described above) are examples of this. In pre- and post-implementation testing, Geisinger has shown they can deliver every desired element of care almost 100% of the time, compared with much lower rates for patients when these automated programmes were not used.

Conclusions and Recommendations

• Adding CPOE, CPOE-driven decision support (including order sets), and other modern EMR functionality to a hospital without these capabilities should support a 10% reduction in average hospital lengths of stay for a typical hospital. However, achieving these reductions will require innovative process and practice changes. Expansion in the sophistication and effectiveness of decision support can yield LOS benefits, even when CPOE and basic decision support are already in place.
• Make CPOE mandatory as early as possible in an EMR implementation to achieve big clinical and financial dividends.
• Complete a careful analysis of processes affecting ALOS, in order to understand unique local issues and sub-process performance, and then design surveillance and other advanced decision support interventions to address those unique issues.
• Focus on specific groups of patients, units/locations, time periods, situations, etc., in which the EMR can be expected to show its greatest impact, rather than trying to measure the impact of the EMR on average hospital LOS for all patients.
• Measure IT-related LOS impacts carefully on a monthly basis as interventions are rolled out, and system design and workflows are adjusted to optimise positive effects. Monitor additional quality measures such as mortality, complication rates, and readmissions concurrently with LOS reduction efforts to ensure that LOS reductions are not negatively impacting quality.