



Using Electronic Health Records to Improve Quality and Efficiency: The Experiences of Leading Hospitals

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Abstract: An examination of nine hospitals that recently implemented a comprehensive electronic health record (EHR) system finds that clinical and administrative leaders built EHR adoption into their strategic plans to integrate inpatient and outpatient care and provide a continuum of coordinated services. Successful implementation depended on: strong leadership, full involvement of clinical staff in design and implementation, mandatory staff training, and strict adherence to timeline and budget. The EHR systems facilitate patient safety and quality improvement through: use of checklists, alerts, and predictive tools; embedded clinical guidelines that promote standardized, evidence-based practices; electronic prescribing and test-ordering that reduces errors and redundancy; and discrete data fields that foster use of performance dashboards and compliance reports. Faster, more accurate communication and streamlined processes have led to improved patient flow, fewer duplicative tests, faster responses to patient inquiries, redeployment of transcription and claims staff, more complete capture of charges, and federal incentive payments.



INTRODUCTION

Electronic health record (EHR) systems enable hospitals to store and retrieve detailed patient information to be used by health care providers, and sometimes patients, during a patient's hospitalization, over time, and across care settings. Embedded clinical decision support and other tools have the potential to help clinicians provide safer, more effective care than is possible by relying on memory and paper-based systems. In addition, EHRs can help hospitals monitor, improve, and report data on health care quality and safety. The Centers for Medicare and Medicaid Services (CMS) calls EHRs, "the next step in continued progress of health care."¹

Despite the utility of electronic health records, hospitals were initially slow to adopt them. A 2009 survey of American Hospital Association (AHA) members found just 1.5 percent of hospitals had a comprehensive EHR system, meaning that the system performed 24 specific functions and was used in all clinical units. Another 7.6 percent of hospitals had an EHR in use in at least one clinical unit.² Hospital leaders cited startup and maintenance costs as major barriers to adoption.

To accelerate widespread adoption and use of EHRs, the Health Information Technology for Economic and Clinical Health (HITECH) Act, part of the American Recovery and Reinvestment Act of 2009 (ARRA, or the stimulus package), established incentive payments from the Medicaid and Medicare programs for hospitals demonstrating that they are making “meaningful use” of an EHR system to improve patient care. The Office of the National Coordinator for Health Information Technology (ONC) promulgated criteria for the “meaningful use” of EHRs, which include several specific applications of the tool for improved safety and quality ([Appendix A](#)). Hospitals meeting the criteria can apply for payments.

Meaningful-use incentive payments appear to be promoting adoption, possibly in combination with the availability of new and better EHR products and the growing emphasis on integrating care in accountable care organizations. A 2011 update to the 2009 survey of AHA hospitals found that the number of hospitals with EHRs doubled in two years.³ Nearly 2,700 hospitals (just over half of all community and federal hospitals) have earned meaningful-use payments for having purchased, or for having a contract to purchase, an EHR. As of March 2012, payments to eligible hospitals totaled in excess of \$3 billion.⁴ Eighty-five percent of hospitals surveyed reported that they planned to take advantage of meaningful-use payments by 2015.⁵ Using somewhat different criteria, 41 percent of hospitals were thought to be “well positioned” to meet meaningful-use standards as of September 2011, up from 25 percent in February 2011.⁶

This report describes the experiences of nine hospitals that are early adopters and pioneering users of EHRs. While it is not possible to generalize from this small sample, these examples are intended to provide useful lessons and insights for other hospitals, including those that are considering EHR adoption, ramping up their EHRs to meet meaningful-use criteria, or tailoring their EHR to promote health care quality and safety. The report may also provide insights for

policymakers seeking to learn how public policies and incentives may influence hospitals’ adoption and meaningful use of technology.

STUDY METHODS

To identify hospitals for inclusion, we used findings from hospital surveys conducted by the AHA’s Health Forum in 2007 and 2009. Health Research and Educational Trust (HRET, a division of the AHA) analyzed the data and identified hospitals that expanded their EHR functionality from having no EHR or an EHR with a few functions only in some parts of their hospital in 2007 to a “comprehensive” EHR (24 functionalities throughout the hospital) in 2009 ([Appendix B](#)). We consider these hospitals “most improving” in EHR functionality over the 2007–09 period. Hospitals that already had a comprehensive EHR in 2007 were excluded from this analysis in order to limit recall bias about the adoption decision and implementation process. In selecting hospitals the authors also sought diversity in size and geographic region.

We conducted interviews with individuals in the nine hospitals who are knowledgeable about their institution’s EHR adoption. Interviewees included chief information officers at the hospital or health system levels, vice presidents of quality (or executives with an equivalent role), and other staff involved in EHR implementation. The hospitals also provided data, reports, and other materials.

Among the nine hospitals, seven are part of multihospital integrated health systems, of which two (Gundersen and Metro Health) are the only major hospital in their integrated system. None are independent hospitals. [Appendix C](#) provides further details. The nine hospitals are:

- Carilion Roanoke Memorial Hospital, Carilion Clinic (Roanoke, Virginia)
- Doctors Hospital, OhioHealth system (Columbus, Ohio)
- Geisinger Wyoming Valley Hospital, Geisinger Health System (Wilkes Barre, Pennsylvania)

- Gundersen Lutheran Medical Center, Gundersen Lutheran Health System (La Crosse, Wisconsin)
- Metro Health Hospital, Metro Health (Wyoming, Michigan)
- NewYork–Presbyterian Hospital, NYP Healthcare System (New York, New York)
- Sentara Norfolk General Hospital, Sentara Healthcare (Norfolk, Virginia)
- VA Central Iowa Health Care System, Veterans Health Affairs (VHA) (Des Moines, Iowa)
- Yale–New Haven Hospital, Yale New Haven Health System (New Haven, Connecticut)

This report explores the principal drivers behind EHR adoption, key EHR functions, implementation challenges and strategies for addressing them, as well as strategies for enhancing the utility of EHR systems. It also examines the impact of EHR use on health care quality and efficiency, future directions in EHR development, and policy implications.

KEY DRIVERS OF EHR ADOPTION: IMPROVING QUALITY AND CONTINUITY OF CARE

These leading hospitals adopted comprehensive EHRs prior to the availability of HITECH meaningful-use incentives. Executive and clinical leaders believed that a comprehensive EHR would improve health care quality, consistency, and patient safety. At most of the hospitals, adopting a comprehensive EHR was part of a strategic plan to integrate inpatient and outpatient care and provide a continuum of coordinated services across their systems. The EHR was expected to improve communication among providers across care sites. Some interviewees noted that this level of coordination would be necessary for further delivery system reform (such as forming an accountable care organization), and that patients would benefit from and value having a complete and coordinated resource for their medical information across the system.

One hospital noted the potential value of EHRs for gathering information about “frequent flier” patients in particular, in order to better coordinate care for those who have complex conditions and may have trouble keeping track of their own clinical information. Two of the larger systems described improved efficiency as one factor but not the primary impetus behind their investment (the main driver was improved quality and integration). One multihospital system expressed a preference for standardizing care across all hospitals.

A few of the nine hospitals switched from internally built EHR systems or early models of single-functionality EHRs (e.g., radiology-only) to comprehensive commercial models during the study period, while others converted from paper processes directly to comprehensive, commercial products. Those that previously had a homegrown EHR cited improvements in the commercial options as a factor in deciding to make this switch, along with the ability to have one integrated platform for both inpatient and outpatient care.

EHR SELECTION AND FUNCTIONS

System Selection Criteria

In organizations with one flagship hospital, that hospital’s leaders were closely involved in the selection of the EHR vendor and product. In other systems, the EHR selection was generally made at the corporate level, though clinicians and other end-users from the dominant hospitals were involved in the selection and implementation process.

For example, at Sentara Healthcare, the integrated health system that includes Sentara Norfolk General Hospital, the system leaders initially narrowed the options down to two vendors, then videotaped vendor demonstrations of both EHRs’ capabilities. Next, Sentara sent sections of the videos to the relevant departments at its hospitals for comment by the people who would actually use it every day. Roughly 3,000 people were involved in the selection process, including 1,000 physicians. Sentara reported that this process established broad participation in the development and

implementation of the EHR and a foundation for process improvement.

Key criteria behind EHR selection were:

- greatest potential for integration with outpatient care;
- vendor provision of technical support before, during, and after implementation;
- capability for extensive customization; and
- availability of upgrades that help hospitals meet meaningful-use guidelines.

Of the nine, only the Veterans Health Administration developed its own EHR because there were no commercial options available when it began the selection process in 1993.

EHR Functions and Meaningful Use

The hospitals reported that their EHR systems had at least 24 functions related to clinical documentation, test and imaging results, computerized physician order entry, and decision support ([Appendix B](#)).

Interviewees emphasized that an important EHR feature is the ability to add new modules or functions over time, with several hospitals purchasing or developing their own additional components that support particular workflow needs. For example, NewYork–Presbyterian switched from scanning paper consent forms with patient signatures into the EHR, to using signature pads in the emergency department to insert digital signatures into electronic consent templates. Patients sign the signature pads and their signature is recorded in the medical record. The hospital also has begun using real-time medical dictation that incorporates notes directly into the EHR. Recent improvements in voice-recognition technology have made this approach feasible, even in noisy environments such as the emergency department.

Some hospitals noted a need to phase in new EHR modules, such as barcoding tools, because of their expense and the need to manage workloads. With

barcoding systems, patients wear a bracelet that nurses can then scan and match against barcoded medications, blood products, and medical devices to confirm they are administering the right treatments to their patients.

Although not driven by federal incentives to adopt EHRs, all nine hospitals are benefiting from the federal meaningful-use incentive program. To qualify for payments in the first year of implementation, hospitals must self-attest to having or being in the process of acquiring an EHR that meets all 14 core objectives and five of 10 objectives from the “menu set” list, delineated in [Appendix A](#). Core EHR features include the ability to collect and update patient information that is not consistently provided or documented in all hospitals, including a complete medication list and a medication allergy list, smoking status, and demographic data such as preferred language. Each of the nine hospitals met meaningful-use criteria and received EHR incentive payments in 2012, and most also received them in 2011. In the second year of Stage 1 funding, hospitals must demonstrate their capacity to achieve the standards.

By 2014, more challenging Stage 2 standards will be established. Draft standards reveal the next stage will likely require that hospitals demonstrate actual use of many of these same features.⁷ Commercial EHR systems have the capacity to help hospitals meet these requirements, though hospitals will have to design their workflows to keep data current and usable by providers and patients.⁸

Implementation Timeline

Nearly all of the hospitals had intensive, lengthy planning and development phases that involved EHR customization, care process redesign to support use of the EHR, and end-user training. The “design, build, validate” phase took a year or (more often) longer, leading up to a staggered launch at different hospitals and physician practices/ambulatory sites across a health system, generally with a “big bang” implementation (all

departments at once) within any one hospital. This kind of “big bang” implementation is often necessary because of the interconnectedness of all systems and departments within a hospital. Even Geisinger, which rolled out EHR functions in a few stages, emphasized the need to implement new functions across all units in a facility at the same time. Only two IT leaders favored a phased approach that allows for identification of problems before full implementation.

The planning and development period varied among systems and hospitals, but the typical time from the decision to purchase the EHR to implementation was two to three years. None of the hospitals received planning assistance from resources currently available, such as Regional Health Information Organizations (RHIOs), Regional Extension Centers (RECs), or other federally or state-funded technical assistance sources, because these were not in existence at the time.

Connectivity to Ambulatory and Other Settings

In six of the nine health systems, physician practices have an office-based version of the EHR that is fully integrated with the hospital system and can share and modify patient records in real time. In fact, such integration was part of the impetus and objective for EHR adoption. But some hospitals, even some in health systems, are not yet integrated with their outpatient providers due to either the need to stagger implementation or initial resistance from outpatient providers.⁹

Hospitals’ capacity to share information and use of the EHR with unaffiliated community providers varies. Physicians who are not part of the health systems generally have free access to view the records for their patients treated at the hospital, but are not able to add their own notes into the system. The Carilion system gives community providers the option to purchase full use of the EHR (with privacy safeguards), and Metro Health sells its version of Epic to affiliated physicians, while allowing those who have their own

systems to interface with it. The VHA’s EHR is available free of charge to non-VHA providers.

For many of the hospitals, unaffiliated hospitals that use the same type of EHR system may choose to exchange patient information. This is beneficial when a patient is referred outside of the region for specialized care. Some of the hospitals are developing RHIOs or other community partnerships for data-sharing (including Geisinger, Metro Health, and Carilion). Geisinger is also part of a Beacon community, a federal program that provides funding and other support to communities that are making progress in EHR adoption. The Veterans Health Administration has begun to share data with Kaiser Permanente and the Department of Defense.

Patient Portals

The EHRs at seven of the nine hospitals include a portal that gives patients Web-based access to their records. The others plan to add this capability or use flash drives to give patients an electronic copy of their information when requested (in keeping with the Stage 1 meaningful-use requirement). Draft Stage 2 meaningful-use guidance would require at least 10 percent of patients to open and use, or forward, their data, which could drive additional patient portal functionality.

The hospitals’ patient portals enable patients to schedule appointments, ask questions of their physicians, view test results, and order prescription refills. Sentara also offers “e-visits,” which may be used to discuss health issues that do not necessarily require office visits.¹⁰ Interviewees reported that patients’ use of the portals and satisfaction with them is strong and growing. For example, Geisinger’s portal is regularly used by about 155,000 people, or one-third of patients. The most successful strategies to promote use of the portals included discussions during physician visits and television and radio advertising.

KEY STRATEGIES TO SUCCESSFULLY IMPLEMENT AND OPTIMIZE EHR

Interviewees described several major challenges in making the transition to the EHR system and using it to achieve optimal benefits. Through creativity, commitment, and in some cases trial and error, these hospitals successfully addressed most of the challenges. This section describes the key challenges and innovative solutions.

Challenge: Achieving Physician and Staff Buy-In

Achieving buy-in from physicians and other staff was cited as a critical challenge by interviewees at all of the hospitals. While only a minority of staff members was resistant to electronic health records per se, many physicians and others had significant concerns about the anticipated upheaval and changes in their day-to-day activities. Their anxiety was compounded by ambiguity about the potential benefits of the new system, as well as wariness about new clinical rules being imposed on them.

Solution: Strong Leaders Who Are Both Forceful and Realistic

Hospital and health system leaders used varied approaches to demonstrate that implementing EHRs was a high priority. All of the hospitals committed significant financial resources toward equipment, software, IT staff, and training. They also kept the new system at the forefront through high-level meetings over months and even years. Sentara held “eCare” meetings for four years: twice each month for sites that were preparing for EHR implementation and for those already operational. Sentara also holds executives accountable by setting targets related to EHR use (as well as other performance measures), and tying 20 percent to 30 percent of compensation to meeting the goals. One interviewee noted that these financial

incentives contribute to their achievement of 87 percent sustained computerized physician order entry (CPOE) use.

To spread momentum for EHR implementation, some hospitals focused their early efforts on departments with strong leaders who could drive change and hold staff and physicians accountable, while also helping them work in the new system. Similarly, it was helpful to focus EHR-based quality improvement efforts initially in areas with strong clinical leadership.

It also was important for leaders to promote the goal of achieving an integrated system. To do so, hospitals used meetings, announcements, newsletters, and e-alerts to communicate the potential benefits of integration, and to celebrate their staff members’ achievements in using the EHR. Carilion, for example, highlighted in various communications examples of both patients and providers drawing information from the EHR to make informed decisions.

Leaders sought to demonstrate that they understood the difficulty of EHR adoption. They emphasized that making the transition to EHR use is not a one-time task but an ongoing process of updates and improvements. Setting realistic expectations fostered trust.

Finally, a successful transition also depended on leaders occasionally taking a tough stand. This meant not tolerating disruptive or resistant behavior. In some cases, a hospital fired individuals who refused to use the new system after repeated efforts at persuasion. Leaders’ overriding message about EHR adoption can be summarized by the mantra at Geisinger (which did not have to fire anyone): “Failure is not an option.”

Solution: Involve Clinical Staff in EHR Design and Implementation

All interviewees emphasized that the most important factors in building support for the EHR were having clinical staff drive the process (with billing and other

Examples of Hospitals' Use of Clinical Teams for EHR Development

Gundersen Lutheran	The hospital gradually put together a 50-person clinical team primarily comprising nurses with a few physicians focused on information services. The team focused on ensuring that the EHR was built with patient care as its top priority. They also helped train other staff in use of the new system.
Metro Health	A "core Epic" team of about 100 FTEs was established and met regularly for 18 months; it included nurses, physicians, and staff from throughout the hospital system who focused on workflow.
Carilion	The parent health system used a three-level implementation team: <ul style="list-style-type: none"> • executive team with direct oversight of the project; included hospital COOs, CMOs, CNOs, CEO of ambulatory care, and others; • steering committee that developed policies and procedures; and • operating team comprising frontline staff who incorporated the new system into daily processes in the hospitals and other sites.
Sentara	The parent health system brought in 185 people (many of them floor nurses) from across the integrated system, trained them on the new EHR system, and then sent them back to teach others. These "super users" are embedded throughout the organization and called on whenever there is a need to tweak or modify the system.
NewYork–Presbyterian	The hospital used clinical specialists to break up the EHR's note template into structured fields so that information can be extracted for meaningful-use data reporting. It also has a House Staff Quality Council with an IT subcommittee that meets monthly and discusses issues such as improving hand-off communication using a custom EHR feature, developing an electronic checklist to track safety and regulatory requirements, and working to prevent alert fatigue.
Geisinger	The parent health system selected the "best and brightest" in the organization to implement the EHR. Inpatient implementation involved a physician optimization team, a nursing "super user" team, and an inpatient EHR project IT team for analysis, system development, and issue tracking and management.
Yale–New Haven	The system buys physician time away from practice so as not to penalize them for being involved in customizing the EHR; prior to the rollout of the new EHR, scores of physicians worked on customization every Tuesday morning.

administrative functions "following along") and involving as many staff as possible in its design and development. Even though most hospitals purchased commercial EHR systems, they required a great deal of customization at the system and hospital levels. In addition to forming high-level implementation teams, key staff members throughout the hospital were assigned to design teams and committees to help tailor the EHR system to the hospital environment. This approach, which reassured personnel that their opinions and expertise mattered, nurtured a sense of ownership and buy-in to the EHR system and alleviated concerns that administrators were imposing an external system on them. It also created experts who could guide their colleagues.

To build support for the EHR among physicians, the hospitals identified and nurtured physician

champions. These individuals were either proponents of adopting a comprehensive EHR from the start or became enthusiastic early in the process, and were viewed as having influence over other physicians. Physician champions educated their colleagues about the benefits of the new EHR in their workday, emphasizing that it does not increase their burden but actually reduces the time spent returning phone calls and searching for charts, lab results, and other information; improves patient safety; offers decision support; facilitates care for patients from the office or home; and aligns with the Institute of Medicine's quality goals.

In addition to recruiting EHR enthusiasts, Sentara also recruited skeptics. Working with the designers until the EHR met their needs convinced skeptical physicians of the value of the EHR, and they became among its strongest champions.

Challenge: Training

The hospitals faced tremendous logistical challenges in training virtually all hospital staff and many community clinicians in how to use the EHRs. They needed to expand their IT staff to work with the EHR vendor to customize the system, including adding IT-focused clinicians who could bridge the conversation between technology and practice. Integrated health systems had to coordinate implementation and training both at central facilities and at more remote “offsite” locations. After the transitions to the comprehensive EHRs, training needs continued as new staff members are hired and changes/updates are made to the system.

Solution: Invest Heavily in and Require Training

While commercial EHR vendors (used by eight of the nine hospitals) generally provide EHR staff training to some personnel, the hospitals had to extend training to virtually all clinical and administrative staff as well as community physicians. The hospitals found they had to make significant investment in training. According to one interviewee, “If you short-change training, you will bring productivity to a halt.”

In addition to training hospital staff, integrated health systems trained physicians in their owned and affiliated practices that were adopting the medical office version of the EHR. And most also offered training to community physicians who had different office medical record systems but admitting privileges; this enabled them to add to the medical record when treating patients at the hospital and to access information from the EHR hospital record for their patients (generally through a Web portal).

Hospitals and systems with remote, rural clinics faced logistical challenges to training. Gundersen addressed this by creating hubs whereby teams from three or four clinics distant from the hospital but in proximity to each other were trained together. This resulted in “super users” in each clinic who would then train their colleagues.

A key policy across the hospitals is that training is not voluntary: all employees and clinicians are required to attend training and pass a proficiency test to access the EHR system and have the ability to go on rounds.

Examples of Hospitals’ Strategies for Training Physicians and Staff

Gundersen Lutheran	Stick to what is necessary: For the small portion of physicians who were opposed to using an EHR, focusing only on the EHR functions needed to care for patients helped them learn the critical components. Nevertheless, some staff did choose to retire or move on.
VHA	Offer simple tools: In addition to formal training, pocket cards were available for physicians with reminders of how to perform common EHR functions.
Geisinger	Provide personal assistance: “Shadowers” followed physicians and nurses through the day to provide assistance during the transition phase. Over time, the hospital was able to reduce the number of training staff from more than 100 to just two to three.
Doctors Hospital	Use clinicians as IT educators: Even after development and implementation, clinicians were kept in IT roles. For example, a family physician is a vice president in the IT department, chairs the IT steering committee, and has four to five physician education specialists supporting other physicians. He also rounds on the floors and appears at the physicians’ dining room with computers, demonstrating new functions and answering questions. Other IT staff go on rounds to support staff use of the EHR system.

Challenge: Performance Improvement

A major challenge at all of the hospitals was to optimize use of the EHR systems to improve health care quality and efficiency. In the early stages, the challenges were to streamline processes while maintaining quality, to design and tailor the EHR to promote standardization while not alienating physicians, and to maximize performance improvement capabilities. On an ongoing basis, the challenges became ensuring day-to-day utilization of the EHR beyond measurement and reporting to active performance improvement.

Solution: Redesign and Standardize Care Protocols

The hospitals used EHR adoption as an opportunity to streamline, standardize, and improve care processes. More efficient and effective protocols are then embedded in the EHR software as guidelines and default order sets.

Sentara used the Lean “value stream mapping” technique when developing their EHR.¹¹ They identified 18 major processes (each with multiple sub-processes) covering the entire continuum of care and recruited subject matter experts to map, streamline, design, and validate each process. Six Sigma teams shadowed staff who were conducting the original process, held practice drills by walking nurses through the proposed new approaches, made adjustments, and supported the staff through final changes.¹² Exhibit 1 illustrates Sentara’s order entry process as it was streamlined from 27 to eight steps.

The hospitals had to consider, however, whether changing care processes while shifting to an EHR system would be overwhelming to staff. An alternative approach is to allow staff to keep their familiar workflows during EHR implementation, changing care processes over time as staff become accustomed to the system. The Geisinger implementation team followed this hybrid approach, starting with select changes such as placing limits on verbal orders. Similarly, the implementation team at Gundersen initially limited the

number of automated reminders and gradually added more over time.

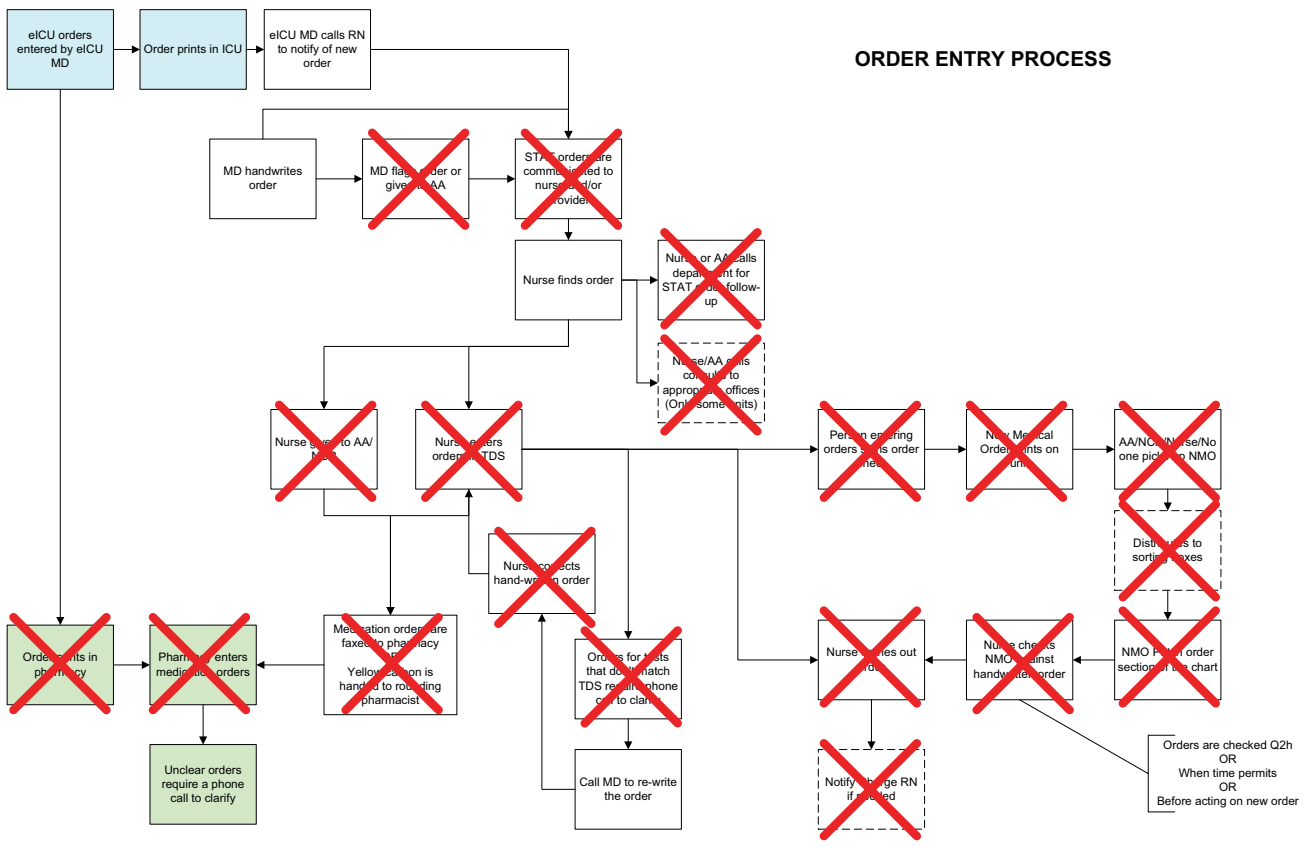
The hospitals also had to decide how much flexibility to give clinicians to deviate from established order sets and guidelines. Part of this decision was whether to incorporate “soft” or “hard” stops in the EHR. Soft stops alert clinicians that an order deviates from a standard; hard stops alert clinicians and stop the order process unless an approved explanation is given to override the standard.

In a couple of the hospitals, leaders realized that physicians were initially permitted too much flexibility in their protocols and order sets in hopes of promoting their buy-in or as part of a hands-off culture. This resulted in variation in practice and poor compliance with quality goals and core measure standards. Leaders then had to limit the flexibility by creating tighter order sets and using more hard stops.

Metro Health and NewYork–Presbyterian ramped up the use of hard stops over time—starting with very few but, as they communicated with doctors about the importance of clinical standards and built consensus, adding more hard stops to ensure all clinicians followed protocols. At NewYork–Presbyterian, the Clinical Decision Support Committee, in collaboration with the IT user group and Housestaff Quality Council, decides when and how to use hard stops. For example, their admission order set cannot be bypassed because it includes steps considered at risk of being overlooked. One element involves prevention of deep vein thrombosis (DVT) or pulmonary embolus (PE) through medication, compression devices, and ambulation. Requiring that each patient have their venous thromboembolism (VTE) risk assessed upon admission has significantly improved compliance with the use of prophylaxis upon admission and reduced DVTs and PEs. Compliance rose from 70 percent to 95 percent after implementation.

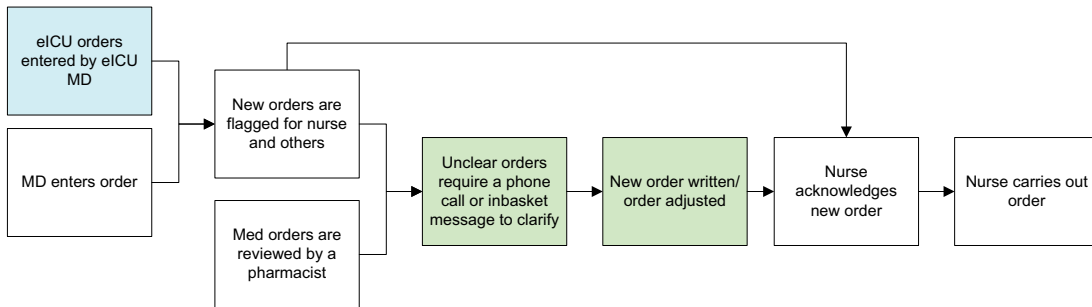
All EHRs allow extensive tailoring of the system to hospitals’ specific needs prior to and after implementation. Multihospital systems regarded standardization across their hospitals as a priority, allowing only minor adjustments (if any) by individual

Exhibit 1. Sentara Order Entry: Original and Streamlined Processes



Streamlined:

ORDER ENTRY PROCESS



Source: Sentara Health System, 2011.

hospitals. For example, when OhioHealth, the system that includes Doctors Hospital, implemented EHRs at the first two of their hospitals, they customized the pneumonia orders. They then asked for feedback from other hospitals in the system on that approach, and ultimately created a single version to implement across

the system. Only Carilion reported that they allow some customization among its hospitals.

All of the hospitals emphasized the importance of involving physicians and other clinical staff in developing the order sets.

Examples of Hospitals’ Efforts to Standardize Order Sets

Gundersen Lutheran	Tasked a clinical implementation team to develop and write order sets; there are currently 600 order sets unique to the medical center’s system.
Metro Health	Established a high-level Clinical Decision Support Steering Committee comprised of physicians, quality leaders, CMIO, COO, and others with an Order Set subcommittee primarily comprising physicians to actually develop the clinical decisions.
Carilion	While standardizing most order sets and protocols to promote evidence-based practices, Carilion made use of Epic’s flexibility to customize the EHR for some care processes, using staff input, so the EHR looks different at each hospital in the system.
Doctors Hospital	Emphasized standardizing care across the entire system, and sought input from clinicians at five hospitals when developing order sets.
NewYork–Presbyterian	Representatives of all five hospitals have weekly team meetings to agree on shared protocols. Physicians are involved in building order sets, notes, and documents. They target full compliance on use of the standard order sets for certain disease conditions (though compliance includes an opt-out, provided the physician enters a valid reason).
Sentara	Recruited subject matter experts from across the health system to map, streamline, design, and validate care processes.

Solution: Embed Checklists in Templates and Place Data in Discrete Fields

The EHR helps but does not supplant hospitals’ previous quality monitoring and reporting efforts. In order to monitor patient care against their own or national standards, the hospitals use the EHR to create checklists to see which patients need additional care, and which patients’ care is in compliance with the standards. The standards are built into a template, which then generates an automatic report to the appropriate staff at selected intervals. For example, several hospitals have daily checks for compliance with CMS core measures.

Creating checklist functionality takes some effort to fine-tune. Early EHR-generated reports at some of the hospitals showed poor compliance on some measures. Quality staff traced this to underreporting—rather than failure to provide appropriate care—because of one of two causes: the relevant information was in free-text (unstructured) fields, which cannot be queried for use in a report, or in another data field that was not part of the report. Hospitals worked iteratively at improving reports and managing data fields to simplify reporting and ensure that clinicians provide

complete information, particularly the reasons for departure from an accepted protocol, to avoid underreporting. Exceptions based on comorbidities, allergies, and selected other circumstances are allowed but must be documented. The more hospitals used the data for monitoring and reporting, the better clinicians became at documenting their work. Still, for certain important measures, such as those reported externally, most of the hospitals continue to rely on quality department staff to manually review the electronic health record to check that reports are accurate and complete.

In all cases, the EHR is most useful when the data needed exist in discrete fields, so that they can be aggregated, sorted, and manipulated. Data that exist only in free-text fields require manual intervention to extract and analyze. Some hospitals have been deliberate in structuring data fields to maximize their use and avoid text fields. Others have deferred to their physicians’ preferences for free-text fields, and rely on quality review staff to read through clinicians’ notes to manually extract usable information. Even those hospitals that use manual chart review report that the EHR is an improvement because it eliminates the need to track down paper charts.

Challenge: Using EHRs for Performance Reporting

Some hospitals were frustrated by the limitations of EHRs to facilitate reporting, particularly their inability to generate reports for CMS Hospital Compare or meaningful-use certification. Difficulties include having too many free-text fields or a mismatch between the reporting requirements and data storage formats, necessitating data abstraction and manual translation. Further, delays in data entry can appear as noncompliance with core measure standards.

Solution: Use EHRs to Aggregate Performance Data

All hospitals use EHR-generated data to report aggregated information about their compliance with care processes and achievement of goals to senior management, quality oversight committees, executive teams, and/or boards of directors. In hospitals where the EHR reports have not been fully customized to produce the desired measures or dashboard, quality staff continue to play a large role in manually preparing these kind of internal performance reports. EHR-generated reports do not allow for extensive manipulation and trend analysis, and may not include benchmarks hospitals find useful. To perform the higher level of analysis and reporting needed, many hospitals export data from the EHR into a separate data repository with greater analytic capacity. For example, Metro Health and Yale–New Haven transfer data from the EHR into repositories and use commercial software for quality reporting and to analyze their performances. Yale–New Haven’s repository populates a corporate dashboard with about 60 measures and individual staff, departments, and units have their own metrics.

Further, hospitals noted that not all external reporting requirements can be met with their EHRs because of the specificity of measures, some of which combine data from multiple fields and thus require manual report generation. There may also be problems in reporting compliance with the CMS core measures,

since a delay in data entry can appear to be noncompliance. For example, blood culture before antibiotic administration, usually separated in time by a few minutes, may appear out of order if the medication administration is recorded before the blood draw. For these reasons, it is common for hospitals to use the EHR to start the reporting process, but then manually audit to ensure documentation is complete and accurate. If data are missing, they discuss it with the unit.

Several hospitals have found it easy to meet meaningful-use standards with their current EHR systems, though some have not. A few hospitals are going through upgrades in order to make it easier to meet meaningful-use criteria, and one hospital delayed its upgrade until the new offering would provide its EHR with the capacity to meet additional, identified needs. With the recent announcement of Phase 2 criteria, hospitals will be looking at their EHR systems’ ability to produce the needed reports.

Solution: Involve Quality Improvement Leaders in Developing and Updating EHRs

Integrating quality tracking and reporting into the EHR is the best way to promote alignment with external reporting requirements. To achieve this, the hospitals included quality improvement and accreditation personnel in the selection, design, and tailoring of their EHR systems. Such personnel can, for example, ensure that order sets and checklists are aligned with best practices and that appropriate data are accessible for reporting, analysis, and improvement. Several hospitals noted that their quality staff worked with IT staff to customize dropdown menu choices in the EHR to be consistent with many of their external reporting requirements.

Such partnerships must continue beyond implementation as standards and reporting requirements change. The hospitals also found it easy to be overwhelmed by all of the data available from comprehensive EHRs. They addressed this by setting priorities and boundaries to help staff focus on the right measures. This too must be accomplished through collaborations among quality leaders, clinicians, and accreditation/compliance experts.

Challenge: Cost and Timing

Adopting a comprehensive EHR is an expensive and long process. All of the hospitals had to develop strategies to: contain, manage, and recoup costs; time and coordinate the rollout; staff the process; and keep their systems current.

Solution: Keep to Implementation Plan and Schedule

The hospitals’ experiences pointed to the need for leaders to create and stay focused on an implementation plan in order to remain on schedule and within budget. While it is important to collaborate during the process, as discussed above, eventually decisions must be made, if necessary by executive order, in order to make progress.

Sentara’s approach was to “go slow to go fast,” according to Burt Reese, chief information officer. They took time up front for deliberate planning, but then quickly implemented the EHR. Even though they delayed paying for software for as long as possible, their peak spending rate was \$4 million per month (Exhibit 2).

EHR adoption presents major staffing challenges as well. One hospital leader admitted that his institution ran staff too hard and for too long, but did not know how that could have been avoided.

Notably, Carilion’s \$76 million IT capital project came in below budget, which leaders attribute to strict adherence to the planned scope and timeline, and the hiring of temporary staff to assist with the three-year transition. Hiring temporary staff proved much less expensive than hiring permanent staff or consultants.

It is important to evaluate the impact of EHR systems, including gathering baseline data on metrics and functions targeted for improvement through EHR use. This is critical for measuring return on investment and identifying areas in further need of examination and refinement.

Larger systems have the advantage of spreading IT costs across numerous hospitals and other sites. The hospitals and systems we examined generally spend 3 percent to 5 percent of their operating budget on IT annually. An exception is Metro Health, which as the only hospital in its system spends about 8 percent of its operating budget on IT.

All hospital leaders faced tough choices in deciding when and whether to update their EHR systems. As new EHR products with enhanced capacities are made, hospitals must weigh the promise of greater efficiency or additional functions in a new or updated system against the time and resources needed to implement it. Hospitals with homegrown EHRs must continually work to keep their systems current and add to them.

Exhibit 2. Sentara’s Total EHR Costs, 10-Year Perspective

Capital	\$67 M
Operating expenses	\$170 M
Hardware maintenance	\$15 M
Software maintenance	\$50 M
Disaster recovery	\$3 M
Work redesign	\$36 M
Training	\$16 M
Implementation	\$22 M
Ongoing support	\$22 M
Other Nonsalary support	\$6 M
Total cost of ownership over 10 years	\$237 M

Source: Sentara Health Systems, 2011.

Challenge: Encouraging Appropriate Use of EHRs

Hospitals grapple with the ongoing challenge of encouraging clinicians and other EHR users to make the most of the systems. For example, busy clinicians may get into the habit of “cutting and pasting” chart notes as a shortcut, or leaving incomplete or outdated problem lists. Software developers must continue to work to develop systems that fit into clinicians’ workflow, minimizing administrative work and automating tasks as much as possible.

Solutions: Modify EHR Programs to Promote Appropriate Use

An EHR system will prove useful only if it is used correctly and consistently. A common problem among the group of hospitals arose when physicians cut and pasted electronic chart notes from prior visits, rather than considering and documenting new issues. In response, Doctors Hospital modified its program to identify and color-code information that had been pasted, rather than newly entered. This is helping to deter staff from taking this shortcut.

The “problem list” in each patient’s electronic record, to which multiple providers contribute, is intended to provide a complete, concise view of the clinical case. The hospitals have found, however, that clinicians often fail to complete or update the lists, mainly because doing so can be tedious or time-consuming. If a condition is not listed (e.g., because it was not the reason for admission), opportunities can be missed to provide appropriate care for patients. For example, heart failure is a condition that is sometimes absent from the problem list.

IT specialists and EHR vendors are working on solutions to address this problem. For example, voice recognition technologies are being developed to automatically capture problems and other key patient clinical data from dictated visit notes, standardize the data, and save it into the EHR.¹³

IMPACT OF EHR ON QUALITY OF CARE

These leading hospitals find the EHR system is living up to their expectations by helping them improve health care quality and safety. Use of the EHR has improved communication among providers, led to better-coordinated care, and promoted patients’ involvement. Clinical guidelines embedded in the EHR promote consistent use of evidence-based care, and automated systems help to catch and prevent errors. Some, but not all, of these hospitals say that the EHRs also have saved time and produced efficiencies.

Hospitals note that an EHR is one critical tool in their quality arsenal, not the sole solution. For example, Sentara attributes a reduction in their mortality ratio (actual mortalities over expected mortalities) from 2009–11 in part to the EHR’s predictive, safety, and other functions (described below). At all of the hospitals, the EHR is used in conjunction with multiple process improvement and system redesign strategies. For this reason, isolating the impact of the EHR on health care quality was not possible, though the hospitals noted a few direct results.

Targeting Quality Improvement Efforts

The hospitals report that a major benefit of their EHRs has been the ability to look at patterns in performance data to identify problem areas, thereby facilitating quality improvement efforts and identifying opportunities for process redesign. EHRs enable custom data queries based on any number of parameters. Quality staff, department chairs, quality improvement teams, and individual clinicians are able to independently query the EHR to explore their own questions and test hypotheses.

Carilion, for example, developed 15 automated reports on the use of patient restraints, each identifying different aspects of restraint use such as patient demographics, diagnosis, and time of day used. Analysts were then able to see patterns and find solutions to problem areas, contributing to decreased use of restraints. Carilion also examined occurrence of ventilator-associated pneumonia, leading to two types of

improvements. First, they redesigned their electronic flow sheets to make it easier to document provision of appropriate care or reasons for exceptions. Second, nurses created a color-coded nursing dashboard in the EHR that displays completion status of recommended protocols for each patient, including documentation of pneumonia risk levels and vaccination (Exhibit 3).

Yale–New Haven also looks for quality improvement opportunities by reviewing data for irregularities. A problem that became evident through routine data review was the apparent underuse of heparin, a blood thinner used to reduce the risk of clots, particularly after surgery. Through discussion with physicians and review of the ordering options embedded in the EHR, it became clear that physicians were in some cases hesitant to prescribe heparin out of concerns for achieving the right level of anticoagulation, knowing the risk of overdosing was harder to manage than underdosing. Based on the combination of data review, interviewing, and process analysis, the hospital added more frequent monitoring of patients on heparin by nurses, which made it possible for doctors to increase doses. Following the process change, anticoagulation use consistent with guidelines increased from 60 percent to 95 percent of patients.

The Central Iowa VHA has used its EHR system to identify problem areas and, as a result, improved the instructions embedded in the EHR to guide physicians. For example, the VHA has

built templates showing the control limits for various laboratory test and vital signs, making it easy to identify patients whose clinical indicators are out of range. This tool can show information longitudinally and at a point in time, enabling physicians to track patterns in outcomes as well.

Performance Reporting and Accountability

The hospitals use their comprehensive EHRs, often in conjunction with additional quality reporting programs, to generate performance reports with trends and benchmarks. The reports, which include data at the physician, department, and hospital levels, are shared with clinicians and other staff to support quality improvement work as well as with joint quality committees, boards of directors, and executives to promote accountability.

Improved Communication

These leading hospitals report the EHR contributes to faster, more accurate communication between providers within the hospital and between ambulatory and hospital settings. Patients’ care plans, medical histories, allergy lists, medication records, and notes are easily accessible, enabling authorized users to see the complete medical story. Information from past visits is available and, when inpatient and outpatient records are linked (as is the case in most but not all

Exhibit 3. Carilion Nursing Dashboard

my PLAIT PCU RMH (12 Patients)			as of 1556									
Patient Name ▲	Age/Sex	Bed	Admission Date	IP Admission Allergies	IP Admission Care Plan	IP Admission Gen Info	IP Admission Pneumo/Flu	IP Admission Flu/Pneumo Vac	IP Admission Risk	IP Admission ROS	IP Admission VTE	IP Admission Learning Assessment
			11/29/11	●	●	●	●	●	●	●	●	●
			12/1/11	●	●	●	●	●	●	●	●	●
			11/30/11	●	●	●	●	●	●	●	●	●
			11/22/11	●	●	●	●	●	●	●	●	●
			11/15/11	●	●	●	●	●	●	●	●	●
			11/18/11	●	●	●	●	●	●	●	●	●
			11/30/11	●	●	●	●	●	●	●	●	●
			11/29/11	●	●	●	●	●	●	●	●	●
			11/29/11	●	●	●	●	●	●	●	●	●
			12/1/11	●	●	●	●	●	●	●	●	●
			11/21/11	●	●	●	●	●	●	●	●	●
			11/28/11	●	●	●	●	●	●	●	●	●

Source: Carilion Clinic, 2011.

of these hospitals), clinicians can access longitudinal information for treatment and discharge planning. Physicians in the Central Iowa VHA system, for example, know whether a patient has at any time had a mental health diagnosis that may be relevant to their current admission.

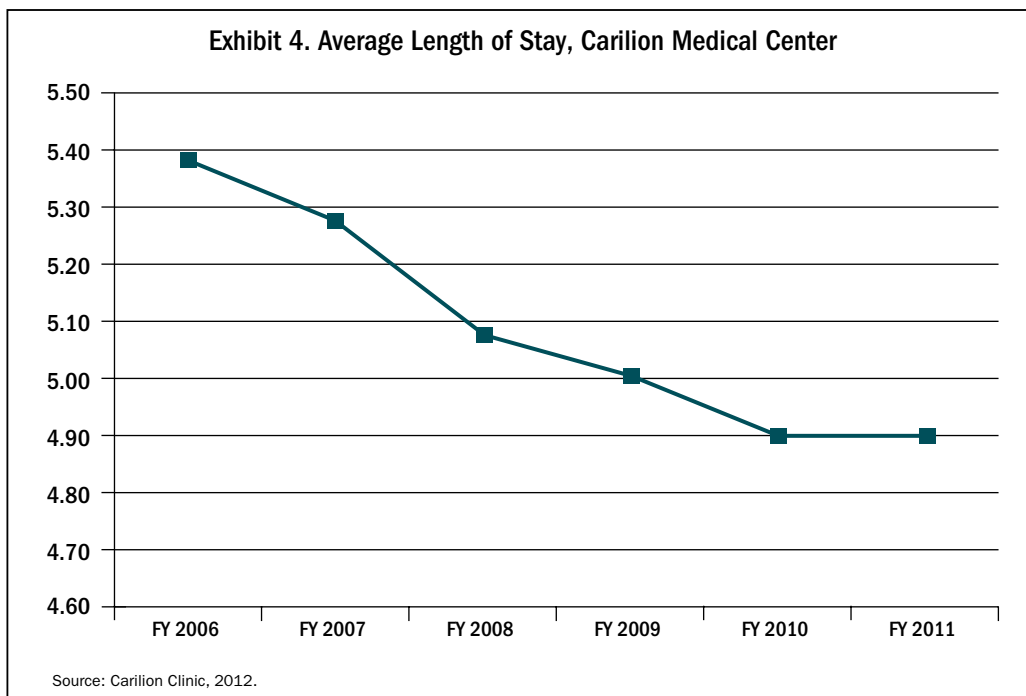
The VHA has found communication across settings to be particularly useful for their patients on home monitoring. Home monitoring data such as vital signs are added to the medical record and available to all providers. Sentara found the EHR streamlined medication delivery: the average time from written order to medication administration decreased from 132 minutes with paper-based records to 38 minutes with the EHR. Hospitals also noted that the EHR makes more data available while the patient is in the hospital, enabling them to make timely corrections to medication regimens or care processes that improve outcomes.

According to Carilion leaders, through faster and more accurate communication and coordination among providers and with patients, the EHR has contributed to shorter lengths of stay and reduced numbers of readmissions (Exhibit 4).

Many hospitals make use of a customized discharge planning tool that has made discharge faster, improved the process of instructing patients, and

strengthened communication among providers and families. At Geisinger, care managers developed discharge flow sheets that are used to discuss progress and next steps during interdisciplinary team meetings. To communicate to the team when it is time to prepare for a patient’s discharge, a “discharge button” is triggered in the EHR and an electronic notification is sent to the staff involved in discharge (e.g., pharmacists, therapists, and case managers) to facilitate completion of tasks required prior to discharge. Red lights and green lights indicate which providers have signed off on a patient’s discharge, helping coordinate the work of the clinicians involved. Yale–New Haven has linked the EHR information to a tracking board on the wall of inpatient units, which helps staff share information such as new orders posted and discharge status.

In systems where the same EHR is used by inpatient and outpatient providers, the outpatient providers have valuable information about inpatient care—including the fact that their patient was hospitalized—as well as the diagnoses, test results, prescriptions, and discharge instructions. At Carilion, such information is sent to the primary care medical home and used by the care coordinator to plan follow-up care—a process the hospital describes as a “game changer” in promoting coordinated, quality care. The



reverse is also true. For example, when a patient arriving at Yale–New Haven’s emergency department is unable to communicate about his past diagnoses, emergency department physicians are able to look at past outpatient and inpatient experiences to guide treatment decisions.

The EHRs also have improved the peer review process. Easy access to time-stamped orders, dispensing information, and administration records has made it easier to identify the causes of errors. There is also better information about what was communicated between clinicians, creating less opportunity for disagreements about which parties are responsible for decisions.

Finally, the EHRs appear to be encouraging patients to play active roles in their care. Carilion reported that patients using the patient portal are starting to drive decisions and become more involved in managing their chronic care.

Consistent, Evidence-Based Care

These leading hospitals embed clinical guidelines in their EHR systems. As described above, they follow structured processes for considering and selecting optimal practices and gaining consensus among clinicians and other essential staff. One interviewee from a teaching hospital said that any medical resident or community physician could come to their hospital and “do the right thing” because of the EHR’s clinical guidelines. Another hospital system reported achieving high levels of consistency across multiple hospitals.

In some cases, clinical guidelines have raised providers’ concerns about “cookbook medicine.” To alleviate them, hospitals do allow order sets to be modified for specific circumstances. For example, at Yale–New Haven Hospital, about 80 percent of ordering is guided, with prompts and questions to help clinicians select the best drug or treatment protocol. Pharmacists-in-training identify patients whose care is not consistent with a reportable standard, and reach out to the physician or floor nurse to find out why. In this case, the two-tiered process achieves the hospital’s quality goals. Some hospitals have worked iteratively to improve their alerts for recommended care so they

appear in the right part of the EHR. Dashboards or checklists make it easier for nursing or other staff to monitor compliance with guidelines.¹⁴

EHR systems use automated alerts to inform clinicians when they attempt to place an order that conflicts with care standards, or fail to place an order for a required element of care. Hospitals have paid a great deal of attention to whether to require action (a “hard stop”), suggest action (through the alert), or just record the discrepancy in recommended care for future follow-up. Most limit the number of hard stops so as not to interrupt care processes—using them only in important processes, such as screening for infection upon admission (hospital-acquired infections can result in nonpayment).

A risk with alerts is that clinicians will develop “alert fatigue” and begin to ignore them. Recognizing this, hospitals focus on alerts’ value during staff meetings and when training residents. Some seek to make alert attentiveness part of the culture, and place a high value on clinicians making use of the decision support features of the EHR. Physicians teach their peers about new alerts to gain their buy-in. Some hospitals build in redundancy, so if a physician does not take action, a nurse manager receives the alert.

Some hospitals give physicians reports on the extent to which care for their patients meets recommended standards. Education and discussion among departments can lead to further refinement of protocols and/or changes to care processes.

Predictive Tools

A few hospitals are adding predictive tools to their EHRs to help clinicians anticipate and avoid situations such as heart attacks and readmissions. Geisinger recently added information about patients’ well-being and risk factors, called the Modified Early Warning System (MEWS), to their EHR. The system generates a score using an algorithm based on vital statistics and mental status and then signals providers when close monitoring and prompt intervention are needed. The score is recalculated each time a patient’s vital statistics and mental status are updated. It helps staff

recognize when a patient's condition is worsening, how severe the change is, and what steps to take. In the past, a patient's deterioration sometimes went unnoticed. Now, the Rapid Response Team is called several times a day to check on patients who have very high MEWS scores. As a result, the number of heart attacks has decreased. Geisinger also has developed an algorithm to assess patients' risk of readmissions and seeks to mitigate identified risks.

Sentara developed and is piloting in three hospitals a "smart screensaver" early warning system that displays patient room numbers in three colors: green indicates a patient's vitals are as expected; yellow indicates some deterioration in a patient's condition; and red prompts clinicians to log on immediately to see the problem and decide on a course of action, often calling the Medical Response Team to assess the patient and expedite a transfer or other action. This early warning system has led to a reduction in heart attacks as well.

Improved Patient Safety

Hospitals report that EHRs have been "life savers" by preventing drug interactions, allergy conflicts, and human error in ordering, filling, and administering drugs through functions that compare physicians' orders against standards and verify a patient is receiving the right medication or treatment. The Sentara health system calculated that it avoided 117,400 potential medication errors due to medication barcoding. Gundersen reports in a published study that after implementing its EHR, medication errors per 1,000 hospital days decreased from 17.9 to 15.4. The percentage of medication events (injury caused by a drug) that were medication errors decreased from 66.5 percent to 55.2 percent. The rate of errors caught before they affected the patient per 1,000 hospital days increased from 9.0 to 12.5, which the study authors posit is because some events were identified after EHR implementation that otherwise would have gone unnoticed, and some of what would have been actual medical errors were avoided.¹⁵

The EHR has helped to reduce infection rates by prompting staff to follow national infection

prevention guidelines. At Geisinger, for example, the EHR prompts users to supply a reason when a urinary catheter is ordered, and then sends a reminder to remove it at the appropriate time.

NewYork–Presbyterian created a patient identification module to avoid having physicians mistakenly enter orders on the wrong patient—a problem that has been well described in the literature as an unintended consequence of the electronic medical record.¹⁶ These types of errors occur more easily when working with an electronic list of patients, given the ease of juxtaposition and other mechanisms when physicians have to choose a patient from an extensive listing. When a physician clicks on the order entry icon to place an order, a large patient verification screen opens that displays the patient's name, medical record number, and date of birth in a large font size. In addition, the screen includes other "triggers" that help confirm that the physician has selected the correct patient. These include the resident and attending physicians' names, the admission diagnosis, the patient's gender, and a list of the most recent medications ordered for him or her. The EHR cannot be advanced past this screen for three seconds—a forcing function that encourages a careful review of the data presented.

Finally, quality improvement staff say that having EHRs reduces errors related to use of handwritten orders (i.e., poor legibility) and helps patients read discharge instructions.

EFFICIENCIES AND RETURN ON INVESTMENT

More Time for Patient Care and Quality Improvement

There is some disagreement among the hospitals about the extent to which their EHR systems save time for providers. Several of those interviewed reported that they spend more time documenting care on the EHR, and one person claimed that electronic ordering takes twice as long as paper ordering. But all note that this is outweighed by time savings in other areas. For example, Sentara nurses found the EHR-based

discharge tool reduced the time spent searching paper records for relevant information. Clinicians do not have to return to the unit to access patients' records; they can access them throughout the hospital, from physician offices, and even at their homes. Physicians said the ability to finish their work and follow up with patients in this way makes them more efficient and strikes a better balance between home and work life. Most of the evidence on the impact of EHRs on clinicians' time is anecdotal. Still, one hospital found that the amount of time nurses spend on direct patient care, as opposed to administrative tasks, increased from 42 percent before implementation to 51.4 percent after EHR adoption.

Quality improvement staff found that EHRs made performance reporting faster and more efficient, thanks to improvements such as the ability to retrieve and review charts remotely and to easily find information on standardized charts.

Improving Throughput and Reducing Redundancy

The hospitals report that the EHR improved patient flow, or "throughput," because care processes can be streamlined and discharges are more predictable and can happen earlier, leading to shorter lengths of stay and faster bed turnover and reassignment. One hospital reported more discharges by 11 a.m. because of better coordination and the use of the electronic patient status board. At Sentara, the time to assign a bed for a newly admitted patient has decreased by 90 minutes, with an 80 percent reduction in time to admit an emergency department patient.

Hospitals reported that EHRs reduce redundancy in test ordering because clinicians can more readily find past test results and are alerted to similar tests ordered recently. NewYork–Presbyterian noted that the EHR could be used to prevent physicians and residents putting in duplicate orders following rounds. The EHR was programmed to alert physicians if an order for their patient had been placed within the past six hours, with an option to continue or cancel a repeat test. After this change, orders for X-rays declined.

Gundersen found that after it implemented its EHR, laboratory tests per week per hospitalization declined by 18 percent, from 13.9 to 11.4. Radiology examinations per hospitalization decreased by 6.3 percent, from 2.06 to 1.93.¹⁷

Redirecting Staff

The hospitals noted that the EHR automatically performs numerous tasks previously done by staff, enabling them to reduce the number of employees or redirect them to other responsibilities. For example, Sentara reduced or redirected to higher-value activities 190 full-time employees. The EHR resulted in less staff time needed for:

- chart review and abstracting;
- note transcription (Gundersen calculated that monthly transcription costs after EHR adoption declined 75 percent, and copy paper orders declined 27 percent);¹⁸
- billing (with automatic entry of charges and claims);
- medical clerk ordering (with computerized physician order entry, or CPOE); and
- patient scheduling (with centralized, electronic scheduling).

Other efficiencies noted by the hospitals included:

- electronic communication with patients facilitates and speeds nurse and physician responses to patient inquiries;
- CPOE results in faster physician ordering of tests, procedures, and medications as well as faster patient receipt of medications;
- a cancelled order is communicated electronically and immediately—faster than a call to the pharmacy, lab, or other provider; and
- better communication with outpatient providers and clearer discharge instructions may contribute to lower readmissions. Sentara found that

readmission ratios dropped by 18 percent at the first four hospitals that adopted the EHR.

Capturing Charges

One aspect of efficiency is being able to bill for all services delivered while minimizing administrative and documentation costs. Through use of an EHR, admissions and orders automatically trigger charges, thereby increasing reimbursement for all services and reducing administrative time spent identifying claims. Gundersen reduced its write-off for care associated with inadequate documentation of services or required Medicare waivers. The hospital's EHR system alerts physicians when a test ordered for a Medicare-covered patient requires notifying the patient of possible non-coverage that would make the patient liable for the cost; the physician can then either obtain the waiver from the patient or change the order to a Medicare-covered procedure.

Meaningful Use and Return on Investment Estimates

Adopting a comprehensive EHR system can help hospitals meet federal requirements to make meaningful use of EHRs and potentially earn incentive payments for doing so. Although the nine hospitals all began the transition to EHRs before these

incentives were implemented, all of them are receiving or expecting to receive meaningful-use incentive payments in 2012, and some began receiving them in 2011. For example:

- Carilion clinic received \$9 million for all of its hospitals, and expected to complete the attestation for its physician practices by the end of 2011.
- Gundersen Lutheran had qualified for hospital meaningful-use payments for Medicare worth about \$2.4 million in 2011, for Medicaid worth about \$2 million, and additional Medicaid meaningful-use payments for its physician practices.
- Sentara received over \$70 million in meaningful-use payments across its hospitals and practices in 2011.

Though all hospitals emphasized that their EHR was one of many factors contributing to efficiencies, a couple of them calculated the return on investment of their EHR. Sentara Healthcare estimated a \$50.7 million annualized benefit in new revenues or reduced costs attributed to the EHR, surpassing its expected benefit of \$38.4 million. The system broke even in the fifth year, and doubled its investment 10 years after EHR implementation (Exhibit 5). In one study, the VHA was shown to have improved efficiency by 6 percent per year following the implementation of their EHR, along with other system improvements.¹⁹

Exhibit 5. Sentara's Return on Investment in EHRs, 2011 \$38.4 M Expected; \$50.7 M Achieved (annualized)

Benefit category	Benefit (millions)*
Reduced length of stay/Reduced adverse drug events	\$14.7
Increased outpatient procedures	\$9.1
Increased unit efficiency/Retention of RNs	\$10.6
Reduced transcription expense	\$3.0
Reduced medical records supply costs	\$2.1
Reduced medical records costs	\$1.8
Reduced Optima (health plan) costs	\$3.0
Reduced other costs	\$6.2
Total	\$50.7

* 2011 for seven hospitals, home health providers, and health plans.
Source: Sentara Health System, 2011.

NEXT ON THE HORIZON

These hospitals are pleased with the EHR-facilitated improvements in health care quality, safety, and efficiency but see further opportunities ahead. Some plan to add new functionality. Others plan to convert older, niche software products to align them with the main EHR used in the hospital. The VHA is moving from a highly integrated, single-EHR system to a more flexible design in which individual modules can be updated and new modules added to follow the patient to other settings. A major redesign is anticipated as the Department of Defense and the VHA plan to integrate their systems to follow servicemen and women after they leave active duty.

For other hospitals, changes will focus on the use of the EHR to further improve practice. Several are making plans to shift from sharing information and establishing the EHR as the evidence base for care to focusing on analytics and greater use of information for clinical decision support and surveillance, improved workflow, and clinical research—optimizing the use of data for proactive quality and process improvement. For example, hospitals plan to use their EHR systems for predictive analytics to change the course of care before a crisis; two hospitals are already testing patient vital sign algorithms to predict problems and intervene early.

CONCLUSION AND POLICY IMPLICATIONS

This examination of hospitals that adopted and/or expanded to comprehensive EHRs between 2007 and 2009 strongly suggests that such systems are an integral part of efforts to promote health care quality, patient safety, and efficiency. Hospitals used their EHRs to facilitate performance measurement, monitoring, and improvement. They assisted providers in crossing boundaries to exchange information and coordinate care across their health care system. The systems have helped promote evidence-based care through standardized electronic order sets, clinical guidelines, and immediate access to medical literature. The systems also help to improve patient safety through features such as automated alerts and

reminders and through new predictive analytics that identify potential problems before they become crises.

Further, the EHRs have enhanced efficiency by alerting clinicians to duplicate orders, enabling faster prescribing and other orders, and reducing transcription, medical records, and claims expenses. All of the hospitals noted the difficulty of isolating and quantifying the impact of the EHR, given that other improvement strategies were employed over the same period of EHR adoption. Nevertheless, they view their investment in the EHR as necessary and part of doing business. One hospital system that measured its impact estimated significant savings from the EHR, and a positive return on investment in five years of implementation.

For an EHR system to be used successfully, it must be integrated through a well-designed process and into a receptive culture. Successful implementation depends on active involvement by all levels of staff in selection, development, and peer education. It also requires strong executive and clinical support and leadership. In these institutions, champions emerged who were instrumental in bringing their colleagues along. Further, implementation is not a one-time event, but an ongoing process of testing and modifying to make the EHR more effective.

Importantly, to realize the full potential of a comprehensive EHR, its adoption must be part of a strategic plan to promote an integrated, patient-centered continuum of care. It is an effective tool for improving coordination of care through faster and more accurate communication across care settings and between clinicians and patients. However, the EHR does not change practice by itself, and workflows must be designed to support the use of valuable information contained in the EHR.

The EHR system also must be part of a broader institutional culture in which quality improvement efforts, including monitoring performance, goal setting, and accountability, are part of day-to-day operations. Quality department leaders should be involved early in the process of tailoring the EHR system to the hospital's needs, and must continue to be involved in modifications on an ongoing basis. This is critical for

integrating quality improvement tools into the technology, and for building regulatory and reporting requirements into the system.

A comprehensive EHR can be a valuable tool for staff training and recruiting. Data about care decisions, and explanations for any decisions that conflict with recommended care, are embedded in the EHR and easily accessible for teaching purposes. A state-of-the-art EHR system can help attract physicians and nurses. One hospital system attributed significant improvement in nurse retention to the EHR and other technologies.

It appears that policy levers can be used to promote adoption and use of comprehensive EHRs in hospitals and health systems. Though the meaningful-use incentives were not the primary force behind EHR implementation at these early-adopter hospitals, these requirements have affected the timing, selection, and modification of their EHR systems. The hospitals are actively seeking and using meaningful-use payments to recoup some of their EHR costs. Further, the rapid adoption of EHRs in hospitals across the United States in this past year, and the American Hospital Association survey finding that 85 percent of hospitals intend to take advantage of incentive payments by 2015, strongly suggest that such policies can accelerate EHR adoption.

The federal government, through CMS and the Office of the National Coordinator for Health Information Technology, has signaled its willingness to set a pace for change that is both ambitious and realistic.²⁰ Eligible providers continue to purchase and

implement their EHRs, a process that can take two years to complete in large institutions. Those who have just made their purchase in 2011 or 2012 may need more time before they can demonstrate effective use. It seems prudent that CMS recently proposed to delay implementation of Stage 2 criteria, which focus on greater use of the EHR functions. However, only by proactively using EHR tools will health care quality, safety, and efficiency improve, so it is important to push forward by setting standards for such changes.

When developing future meaningful-use requirements, policymakers should examine and consider functionalities that are not yet universal but are feasible and show promise among pioneers, such as barcoding and predictive analytics. These could fit in with the current criteria, which will focus on improved health outcomes and population health.

Finally, policymakers can facilitate communication between hospitals that are just beginning their EHR journey and those with substantial experience. Through partnerships with foundations, state hospital associations, and other stakeholders, policymakers and public agencies can convene or fund forums, workshops, and direct technical assistance. As this report has illustrated, there are already many lessons and best practices from the pioneers that can help other hospitals to avoid reinventing the wheel. This will be an ongoing process as providers move through the stages of meaningful use. Early adopters are willing to share.

NOTES

- ¹ <http://www.cms.gov/ehealthrecords>.
- ² A. K. Jha, C. M. Desroches, E. G. Campbell et al., “Use of Electronic Health Records in U.S. Hospitals,” *New England Journal of Medicine*, April 16, 2009 360(16):1628–38.
- ³ <http://www.hhs.gov/news/press/2012pres/02/20120217a.html>.
- ⁴ http://www.cms.gov/Regulations-and-Guidance/Legislation/EHRIncentivePrograms/downloads/Monthly_Payment_Registration_Report_Updated.pdf.
- ⁵ Ibid.
- ⁶ “HIMSS Analytics Report Confirms Increase in Hospitals Expected to Achieve Meaningful Use,” Press Release summarizing “Summary of Meaningful Use Readiness” report, HIMSS Analytics, Nov. 1, 2011. http://press.himss.org/article_display.cfm?article_id=5358.
- ⁷ The proposed rules as released in the March 7, 2012, edition of the *Federal Register* are accessible at <http://www.gpo.gov/fdsys/pkg/FR-2012-03-07/pdf/2012-4443.pdf>.
- ⁸ CMS released preliminary guidelines for Stage 2 in February 2012 (published in the March 7 issue of the *Federal Register*), to be finalized during the summer of 2012 (estimated).
- ⁹ Among the three hospitals that reported lack of full integration with outpatient sites, there is some electronic interface and limited data-sharing possible between the hospitals and outpatient providers. One of these hospitals is planning to switch EHR systems and expand integration with community physicians.
- ¹⁰ Examples of possible topics for e-visits may include sinus infections, uncomplicated urinary tract infections, or follow-up on well-controlled chronic problems such as hypertension.
- ¹¹ Originally developed at Toyota, value stream mapping is used to analyze and design the flow of materials and information required to bring a product or service to a consumer. Lean is a manufacturing philosophy of preserving value with less work and optimizing flow by eliminating wasteful steps.
- ¹² Developed at Motorola in 1986, Six Sigma is a process for improving efficiency by standardizing processes to reduce variation. Six Sigma teams are trained to define clear goals for a process improvement, develop metrics to measure the process, implement a way to improve it, and monitor it to make sure it works.
- ¹³ For more information, see: <http://www.healthmgtech.com/index.php/solutions/electronic-medical-records/the-problem-with-problem-lists.html>.
- ¹⁴ Carilion has used its EHR system to create a nursing dashboard so that nurses know when time-sensitive patient care processes are imminent. Similarly, Sentara nurses see a chart in the patient’s record with red, yellow, or green dots for each step in their protocol, supporting more timely and complete care.
- ¹⁵ J. A Zlabek, J. W Wickus, and M. A Mathiason, “Early Cost and Safety Benefits of an Inpatient Electronic Health Record,” *Journal of the American Medical Informatics Association*, March–April 2011 18(2):169–72.
- ¹⁶ S. S. Jones, R. Koppel, M. S. Ridgely et al., *Guide to Reducing Unintended Consequences of Electronic Health Records* (Rockville, Md., Agency for Healthcare Research and Quality, Aug. 2011), available at <http://www.ucguide.org/>.
- ¹⁷ Zlabek, Wickus, and Mathiason, “Early Cost and Safety Benefits,” 2011. Radiology examinations per hospitalization decreased from 2.06 to 1.93 (6.3%; $p < 0.009$). However, no significant difference was found in the number of hospitalizations, patient days per month, length of stay, readmission within 30 days, or case-mix index, and risk-adjusted mortality was similar before and after EHR implementation. In March 2012, a retrospective study appearing in *Health Affairs* suggested that making imaging and lab results available in an EHR was not associated with less ordering of tests by office-based physicians, but rather that access to imaging results was sometimes associated with more ordering of tests. However, the study included only commercially available EHRs in use in 2008, without decision support, and did not include hospital outpatient departments or offices of radiologists, anesthesiologists, or pathologists. (See D. McCormick, D. H. Bor, S. Woolhandler et al., “Giving Office-Based Physicians Electronic Access to Patients’ Prior Imaging and Lab Results Did Not Deter Ordering of Tests,” *Health Affairs*, March 2012 31(3):488–96 and replies.)

- ¹⁸ Gundersen calculated that monthly transcription costs declined from \$74,596 to \$18,938 (74.6%; $p < 0.001$). Reams of copy paper ordered per month decreased from 1,668 to 1,224 (26.6%; $p < 0.001$). Ibid.
- ¹⁹ D. C. Evans, W. Paul Nichol, and J. B. Perlin, “Effect of the Implementation of an Enterprise-Wide Electronic Health Record on Productivity in the Veterans Health Administration,” *Health Economics, Policy and Law*, April 2006 1(Pt. 2):163–69.
- ²⁰ There are two sets of rules. One is the “Medicare and Medicaid Electronic Health Record Incentive Program-Stage 2” from CMS that details how physicians are to use their electronic medical records systems. The other is the “Implementation Specifications, and Certification Criteria for Electronic Health Record Technology, 2014 Edition” from the ONC, which explains certification criteria for the systems used to meet meaningful use. Both CMS and the ONC are located within the Office of the Secretary for the U.S. Department of Health and Human Services (HHS). For more information, see http://healthit.hhs.gov/portal/server.pt/community/healthit_hhs_gov_regulations_and_guidance/1496.

Appendix A. Meaningful-Use Criteria

There are 39 requirements for hospitals to meet for Stage 1 of meaningful use. To qualify for an incentive payment, hospitals must meet all 14 core objectives listed below, five of 10 objectives from the “menu set” list, and all 15 of the clinical quality measures. In 2011, hospitals could attest to the fact that they adopted, implemented, or used an EHR that met the EHR criteria. In 2012, they must submit data documenting EHR use.

Eligible Hospital Core Objectives (all 14 must be met for Stage 1):¹

1. Use CPOE for medication orders directly entered by any licensed health care professional who can enter orders into the medical record per state, local, and professional guidelines.
2. Implement drug–drug and drug–allergy interaction checks.
3. Maintain an up-to-date problem list of current and active diagnoses.
4. Maintain active medication list.
5. Maintain active medication allergy list.
6. Record all of the following demographics: (A) preferred language; (B) gender; (C) race; (D) ethnicity; (E) date of birth; and (F) date and preliminary cause of death in the event of in-hospital mortality.
7. Record and chart changes in the following vital signs: (A) height; (B) weight; and (C) blood pressure. (D) Calculate and display body mass index (BMI). (E) Plot and display growth charts for children ages 2–20 years, including BMI.
8. Record smoking status for patients 13 years old or older.
9. Report hospital clinical quality measures to CMS or, in the case of Medicaid-eligible hospitals, to states.
10. Implement one clinical decision support rule related to a high-priority hospital condition along with the ability to track compliance with that rule.
11. Provide patients with an electronic copy of their health information (including diagnostic test results, problem list, medication lists, medication allergies, discharge summary, procedures), upon request.
12. Provide patients with an electronic copy of their discharge instructions at time of discharge, upon request.
13. Have the capability to electronically exchange key clinical information (for example, problem list, medication list, medication allergies, and diagnostic test results) among providers of care and other patient-authorized entities.
14. Protect electronic health information created or maintained by the certified EHR technology through the implementation of appropriate technical capabilities.

Hospital Menu Set Objectives (five out of 10 must be met for Stage 1)

1. Implement drug formulary checks.
2. Record advance directives for patient 65 years old or older.
3. Incorporate lab test results into EHR as structured data.

¹ Centers for Medicare and Medicaid Services, “CMS EHR Meaningful Use Overview,” https://www.cms.gov/EHRIncentivePrograms/30_Meaningful_Use.asp.

4. Generate lists of patients by specific conditions to use for quality improvement, reduction of disparities, research, or outreach.
5. Use certified EHR technology to identify patient-specific education resources and provide those resources to the patient if appropriate.
6. A hospital that receives a patient from another setting of care or provider of care or believes an encounter is relevant should perform medication reconciliation.
7. A hospital that transitions its patient to another setting of care or provider of care or refers its patient to another provider of care should provide a summary care record for each transition of care or referral.
8. Have the capability to submit electronic data to immunization registries or immunization information systems and actual submission according to applicable law and practice.
9. Have the capability to submit electronic data on reportable (as required by state or local law) lab results to public health agencies and actual submission according to applicable law and practice.
10. Have the capability to submit electronic syndromic surveillance data to public health agencies and actual submission according to applicable law and practice.

Hospital Clinical Quality Measures (eligible hospitals must complete all 15 for Stage 1)

1. Emergency department (ED) throughput – admitted patients median time from ED arrival to ED departure
2. Emergency department throughput – admitted patients – admission decision time to ED departure
3. Ischemic stroke – discharge on antithrombotics
4. Ischemic stroke – anticoagulation for A-fib/flutter
5. Ischemic stroke – thrombolytic therapy for patients arriving within two hours of symptom onset
6. Ischemic or hemorrhagic stroke – antithrombotic therapy by day two
7. Ischemic stroke – Discharge on statins
8. Ischemic or hemorrhagic stroke – stroke education
9. Ischemic or hemorrhagic stroke – rehabilitation assessment
10. Venous thromboembolism (VTE) prophylaxis within 24 hours of arrival
11. Intensive care unit VTE prophylaxis
12. Anticoagulation overlap therapy
13. Platelet monitoring on unfractionated heparin
14. VTE discharge instructions
15. Incidence of potentially preventable VTE

Stage 2 meaningful-use certification, which will begin in 2014, will establish further requirements that will be determined through the rulemaking process. Preliminary guidelines for Stage 2 were released in February 2012, (published in the March 7 issue of the *Federal Register*), finalized after a 60-day public comment period. Although Stage 2 was originally expected to be implemented in 2013, the guidelines delay the deadline for Stage 2 implementation until 2014. They expand on Stage 1 criteria in an effort to further drive safety and quality improvement, without creating major or unanticipated new requirements for hospitals. Where Stage 1 requirements sometimes required providers to have the capability to perform a function, Stage 2 requirements are more likely to require that they actually use that function, for example by setting thresholds for the minimum percentage of the time they must use it. Key criteria in the Stage 2 requirements include:

- Requiring hospitals to meet 16 core objectives and two of four menu items, a similar number as in Stage 1.
- Setting a higher standard for the use of CPOE by requiring that a majority of the orders that providers write be made electronically.
- The rules describe a large number of quality measures that may later become requirements for performance reporting using EHRs.
- Providers must demonstrate that they exchange clinical data electronically, compared with the Stage 1 requirement to show that they have the capability for health information exchange.
- Hospitals must ensure that more than 50 percent of patients have the ability to view, download, or transmit their data electronically, and at least 10 percent of patients must actually do so.

Appendix B. Twenty-Four Functionalities for AHA “Comprehensive” EHR Designation, AHA Surveys

Clinical documentation

- Demographic characteristics of patients
- Physicians’ notes
- Nursing assessments
- Problem lists
- Medication lists
- Discharge summaries
- Advanced directives

Test and imaging results

- Laboratory reports
- Radiologic reports
- Radiologic images
- Diagnostic test results
- Diagnostic test images
- Consultant reports

Computerized provider order entry

- Laboratory tests
- Radiologic tests
- Medications
- Consultation requests
- Nursing orders

Decision support

- Clinical guidelines
- Clinical reminders
- Drug allergy alerts
- Drug–drug interaction alerts
- Drug–laboratory interaction alerts (e.g., digoxin and low level of serum potassium)
- Drug dose support (e.g., renal dose guidance)

Appendix C. Snapshots of Featured Hospitals

CARILION ROANOKE MEMORIAL HOSPITAL	
Description	<ul style="list-style-type: none"> • Carilion Roanoke Memorial Hospital is 763-bed tertiary care facility, regional referral center, and teaching hospital • Largest hospital in Carilion Clinic, a not-for-profit integrated health system in Southeast Virginia that includes eight hospitals and 160 ambulatory practice sites with 600 primary and specialty care physicians
EHR system	<ul style="list-style-type: none"> • Epic
Impetus for EHR	<ul style="list-style-type: none"> • Part of a Carilion Clinic strategic plan established in 2006 for Carilion’s hospitals and ambulatory sites to become an integrated clinic system over a 10-year period • Physicians on both the inpatient and outpatient sides were champions for moving to a fully integrated, interconnected clinic model • A goal was for patients to know they have a comprehensive record to facilitate them getting the continuum of care • Part of integration vision involves collaborating with a major health plan to form an accountable care organization
Interconnectivity	<ul style="list-style-type: none"> • Installed EHR in one outpatient site per week on average, completed in early 2011 • Nonaffiliated community providers have free, read-only access to the record of any of their patients served in the Carilion system, and now have the option to purchase full usage of the EHR (with privacy safeguards) • EHR shares e-images with other systems, connects with other Epic health systems • Not chosen as Beacon community; REC came along too late • Pursuing community relationships for data-sharing; currently connected with one other large system in the area and sharing images electronically with several systems • Piloted patient portal in 2008 (same year as hospital implementation), then expanded
Examples of EHR-facilitated quality improvements	<ul style="list-style-type: none"> • EHR “workbench” creates reports with trends and benchmarks, shared with departments and nursing units for development of quality improvement projects as well as with joint quality committees, boards of directors, and executives to promote accountability • Nursing dashboard alerts nurses when time-sensitive care processes are imminent • 15 automated reports on patient restraints allowed identification of patterns and problem areas that were then addressed, contributing to a decline in use of restraints • Reporting of ventilator-associated pneumonia (VAP) revealed difficulties in documenting compliance with protocols that led to redesign of flow sheets for easier documentation, and some noncompliance with certain protocols that led to nurse creation of a color-coded dashboard that displays completion status of recommended protocols for each patient • Using the portal, patients are starting to drive decisions; more involved in chronic care • The Carilion Primary Care Medical Home coordinators use the EHR to view a patient’s full inpatient and outpatient record, and can communicate easily with inpatient care coordinators and all of a patient’s providers as well as the patient and family • Centralized, electronic scheduling significantly reduces time spent on patient scheduling • Electronic communication with patients facilitates/speeds nurse responses to patient inquiries, and physician making/returning patient phone calls and finding information • CPOE allows faster physician ordering of tests, procedures, and medications • Through faster/more accurate communication and coordination among providers and with patients, the EHR has contributed to reduced length of stay and readmissions

DOCTORS HOSPITAL	
Description	<ul style="list-style-type: none"> Doctors Hospital in Columbus, Ohio, is a 262-bed teaching hospital that is part of the OhioHealth system. It has the second-largest osteopathic medicine training program nationally, training roughly 160 physicians annually. OhioHealth is a not-for-profit hospital and health system with eight hospitals, nine health centers, and a variety of other outpatient facilities and physician practices serving central Ohio
EHR system	<ul style="list-style-type: none"> McKesson
Impetus for EHR	<ul style="list-style-type: none"> EHR adoption started about 20 years ago with nursing documentation. Barcoded medication administration started in about 2007. In 2009, CPOE and physician documentation started in the emergency department, followed about a year later by a complete, whole house implementation. Doctors Hospital was the first OhioHealth hospital to implement the EHR. EHR adoption was driven by the hospital board's interest in quality and safety
Interconnectivity	<ul style="list-style-type: none"> Doctors uses a "home-grown" interface results browser, OhioHealth Results Browser, which makes some hospital information available to outside physicians, including lab results, documentation, and the inpatient record However, when a patient is in the hospital, only limited information is available from the outpatient setting. Laboratory results can be viewed, but the patient's primary care record cannot be shared
Examples of EHR-facilitated quality improvements	<ul style="list-style-type: none"> Added barcoding about five years ago in four hospitals within the system, now expanding to another one—this feature was chosen for its potential to reduce errors The EHR has improved legibility of physician notes, which improves communication between providers and reduces the risk of errors Developed a report as a way of tracking compliance with EHR checklists, particularly core measures. The report "fires" to the nurse manager on the patient's unit throughout the day, notifying staff of steps needed prior to discharge Additionally, patients receive printed discharge instructions—doctors select elements of the instructions, specific to a given condition, and the system generates patient-centered instructions with appropriate language. Doctors can pick from a checklist of "to-do's" for the patient's condition, and the system generates a printable list for the patient to take home Reminders in the EHR have been useful CPOE has decreased medication errors, and when there are errors, it is easier to see where they originated (with ordering vs. filling vs. administration) Using occurrence reports to examine errors has been a very powerful tool for improving quality over time—when there is documentation of an error, the process is more concrete and productive

GEISINGER WYOMING VALLEY HOSPITAL	
Description	<ul style="list-style-type: none"> • Geisinger Wyoming Valley Hospital (GWV) is a 237-bed hospital located in Wilkes Barre (northeastern), Pennsylvania • It is one of three hospitals in the Geisinger Health System, a not-for-profit integrated health system with a total of 820 beds, 63 primary care and specialty care clinics (2.2 million outpatient visits per year), and a health plan with 250,000 members in 42 counties of Pennsylvania
EHR system	<ul style="list-style-type: none"> • Epic
Impetus for EHR	<ul style="list-style-type: none"> • In 1995, Geisinger made the decision to move to EHR to integrate information across inpatient and outpatient sites. EHRs fit their overall strategic vision of being a health service leader in the region and would help manage the continuum of care, utilize resources efficiently while improving care, and help make the quality of care consistent regardless of where patients entered the system; cost savings were also anticipated • At that time, there was not an inpatient product to use, so they started with ambulatory care settings, and later added the hospitals to complete the transformation • The change was driven by executive and senior leadership; physician champions played an important role, while the project was owned by clinical operations and moved forward by information technology leadership
Interconnectivity	<ul style="list-style-type: none"> • The patient record is shared across Geisinger ambulatory care settings and hospitals, with physicians in each able to see and interact (add, order, etc.) with the record. About 2,500 community doctors who are not part of the system can view their patients' inpatient records through Geisinger Connect. Any doctor with admitting privileges can see his/her patients' records and add notes, even off-site
Examples of EHR-facilitated quality improvements (Geisinger Health System)	<ul style="list-style-type: none"> • GWV recently added patients' Modified Early Warning System score, which signals when close monitoring and prompt intervention are needed based on a composite of vital statistics and mental status. GWV reports that this reduced the number of heart attacks • Alerts are widely used to draw attention to protocols. The nurse manager on a floor is alerted if any patients have a medication due (or other needed protocol step) so she/he can follow up with the doctor • When a step in the care process is important to monitor and at risk of being missed, a field created for that step makes it possible to build in an alert when the field is not filled. Alerts can be sent to clinicians with responsibility for achieving compliance. The EHR has helped reduce catheter-associated infections and central line infections. When a catheter is placed, the clinician is prompted for a reason, which then generates a removal reminder that is appropriate to the patient's need for a catheter • Geisinger developed the Discharge Navigator program, a tool in the chart that brings together key information needed to be discussed at clinical team meetings. A red/green light system indicates which providers have signed off on patient discharges and helps coordinate clinicians involved. They expect this tool to improve efficiency • A "discharge button" helps everyone know when a patient is due to leave, so that internal planning can take place. It is 70% accurate in predicting if someone will be able to leave that day, which is sufficient for planning for new admissions • The EHR includes a risk screening tool for readmissions, with 10 questions completed by the floor nurse or in the emergency department that lead to a risk score • Doctors receive reports on their patients' care compared with standards

GUNDERSEN LUTHERAN MEDICAL CENTER	
Description	<ul style="list-style-type: none"> Gundersen Lutheran Medical Center is a 325-bed private, nonprofit hospital located in La Crosse, Wisconsin The medical center is part of Gundersen Lutheran Health System, a nonprofit, physician-led, integrated delivery system that operates in western Wisconsin, northeastern Iowa, and southeastern Minnesota In addition to the medical center, the system includes a large multispecialty group medical practice, regional community clinics, home care, behavioral health services, vision centers, and pharmacies
EHR system	<ul style="list-style-type: none"> Epic
Impetus for EHR	<ul style="list-style-type: none"> Originally built its own EHR in house during the 1990s, but recently shifted to implement a commercially available EHR as products became available; meaningful-use requirements sped the timetable to adopt an outpatient EHR that supported it Gundersen Lutheran has been a self-contained delivery system with employed physicians since the early 1900s, and as a result had a longtime incentive to EHR adoption By 2005, had built a comprehensive, state-of-the-art outpatient EHR, but it soon began to become obsolete. Inpatient records were still paper-based, and order entry was still written by hand and later entered into the electronic system. Better commercial EHRs were starting to become available, making adoption more appealing
Interconnectivity	<ul style="list-style-type: none"> Data can be exchanged with affiliated hospitals and physician practices that have the same brand of EHR as Gundersen, and it has links to unaffiliated providers; outside providers can only view, not edit, the records Gundersen is sharing its EHR license with two critical access hospitals with which it is affiliated but does not own. It is also gathering these hospitals' data for meaningful use, because they lack the capacity to do so themselves
Examples of EHR-facilitated quality improvements	<ul style="list-style-type: none"> The focus of EHR selection and design was patient care rather than external quality standards such as the core measures publicly reported by CMS, but there is strong alignment. Quality measures are built into order sets because these are written by providers from the specialty involved The protocols embedded in the EHR standardize care, and the EHR enables performance tracking at the individual physician level. Monthly reviews are a common practice. The hospital's quality department reviews these results, and the executive committee sees aggregate statistics on a regular basis, for example the number of heart attack patients discharged with the appropriate medication A study of Gundersen's experience* found positive effects on quality, including that: <ul style="list-style-type: none"> medication errors per 1,000 hospital days decreased from 17.9 to 15.4 (14.0%; $p < 0.030$) "near misses" per 1,000 hospital days increased from 9.0 to 12.5 (38.9%; $p < 0.037$), which the study authors argue is because more such events were identified after EHR implementation that would otherwise have gone unnoticed laboratory tests per week per hospitalization decreased from 13.9 to 11.4 (18%; $p < 0.001$)

* J. A. Zlabek, J. W. Wickus, and M. A. Mathiason, "Early Cost and Safety Benefits of an Inpatient Electronic Health Record," *Journal of the American Medical Informatics Association*, March/April 2011 18(2):169–72.

METRO HEALTH HOSPITAL	
Description	<ul style="list-style-type: none"> • Metro Health Hospital (MHH) is a 208-bed acute care osteopathic teaching hospital in Wyoming, Michigan • MHH is part of Metro Health, an integrated health care system serving West Michigan and Greater Grand Rapids region and surrounding areas; it includes MHH and about 15 neighborhood physician offices, inpatient and outpatient specialty services, a cancer center and other programs; more than 200 physicians have privileges at MHH as either employees or affiliated physicians
EHR system	<ul style="list-style-type: none"> • Epic
Impetus for EHR	<ul style="list-style-type: none"> • Metro Health’s leadership’s decision in 2003 to pursue EHR adoption in the hospital and outpatient offices was based on: <ul style="list-style-type: none"> ◦ increased awareness of patient safety issues after the landmark Institute of Medicine report on this subject ◦ understanding that inpatient and outpatient providers and patients need to work together to better understand and respond to health issues, requiring sharing information in real time ◦ belief by leadership that the future is electronic
Interconnectivity	<ul style="list-style-type: none"> • Every employed physician has access to the EHR • Sell Epic system to affiliated physicians, but some have their own electronic health record system in which case Metro Health attempts some interfacing with them • Sends “after-emergency room visit summary” to any physician with ER patient • Cofounded and currently board of regional information exchange, for sharing of data with other hospitals and physicians • Has MyChart patient portal, used by about 20,000 (early 2012)
Examples of EHR-facilitated quality improvements	<ul style="list-style-type: none"> • Focused first on use of the EHR for sharing information and establishing EHR as a framework. Now MHH is focusing on using the information for quality improvement through clinical decision support and surveillance, workflow improvement, outcomes, and use of data • Core measure compliance declined for first six months to year, and then improved • In certain categories, medical errors have declined • No longer have problems with physician handwriting • Best practice alerts on drug interactions are useful • Care coordination and continuity of care have improved

NEWYORK–PRESBYTERIAN HOSPITAL	
Description	<ul style="list-style-type: none"> NewYork–Presbyterian (NYP) is a 2,409 bed teaching hospital in Manhattan comprising two medical centers (NYP/Columbia University Medical Center and NYP/Weill Cornell Medical Center) as well as a community hospital (NYP/Allen Hospital), the Morgan Stanley Children’s Hospital, and the NYP/Westchester Division for behavioral health. NYP is affiliated with two medical schools (Columbia and Cornell)
EHR system	<ul style="list-style-type: none"> Eclipsys
Impetus for EHR	<ul style="list-style-type: none"> Each hospital had initially followed an independent path to EHR adoption, some with paper and some with early EHR models. Alignment took place from 2006 to 2008 as all five inpatient facilities moved to the same EHR product Cross-hospital policy alignment is a goal; guidelines and checklists are identical across the two main hospitals
Interconnectivity	<ul style="list-style-type: none"> There is limited ability to transfer documents and problem lists between several of the EHRs in use (private practice office spaces) but NYP is currently using PDF automated transmission to improve these capabilities as well as active work on true interconnectivity of several systems to include unique problem lists, medication lists, and document archiving across platforms
Examples of EHR-facilitated quality improvements	<ul style="list-style-type: none"> NYP has extensively built order sets, notes, and documentation fields, involving physicians, with concrete quality results. In general, on many orders, the goal is 100% compliance, though compliance includes an opt-out with a reason where appropriate After starting EHR implementation without hard stops, NYP later began building them in to improve compliance to standards. NYP uses a Clinical Decision Support Committee to decide when to use hard stops. They support doctors in understanding the importance of the hard stops, and the topic is discussed and approved by the House Staff Quality Council, user groups, and the Executive Quality and Patient Safety Committee. They chose to create an NYP Admissions Order Set that cannot be bypassed, and includes essential information, including deep vein thrombosis (DVT) prophylaxis. Appropriate prophylaxis against the development of DVT/PE is now at 95% after implementation compared with 70% prior to the initiative NYP has a patient identification feature developed to avoid the problem of clicking on the wrong patient and mistakenly entering orders, a problem that can happen more easily with an electronic list of patients than in paper orders. Since implementing this feature, they have reduced wrong-order writing errors by 70%

SENTARA NORFOLK GENERAL HOSPITAL	
Description	<ul style="list-style-type: none"> • Sentara Norfolk General Hospital is a 525-bed tertiary care facility in Norfolk, Virginia, that is part of the not-for-profit Sentara Healthcare health system, which serves Virginia and northeastern North Carolina. The system includes 10 acute care hospitals, outpatient campuses, imaging centers, nursing and assisted-living centers, two home health and hospice agencies, and three medical groups with 618 providers. Sentara also owns Optima Health, a health plan that serves 433,000 members in Virginia
EHR system	<ul style="list-style-type: none"> • Epic
Impetus for EHR	<ul style="list-style-type: none"> • Sentara’s leadership understood in the late 1990s that an electronic system linking its ambulatory practices with inpatient care and using uniform guidelines and protocols would improve continuity and quality of care as well as achieve economies of scale • They did not find any appropriate products on the market then, but looked again in 2003. After assessing the impact and making a business case in 2004, Sentara Healthcare signed a contract with a vendor in 2005
Interconnectivity	<ul style="list-style-type: none"> • All admitting and community physicians can see their patients’ records (Epic View) • ‘MyChart’ patient portal used by about 70,000 patients, about 100 users each day (early 2012)
Examples of EHR-facilitated quality improvements (Sentara Health System)	<ul style="list-style-type: none"> • Sentara developed and is piloting in three hospitals a “smart screen saver” early warning system that displays patient room numbers in three colors: green indicates patient vitals are as expected; yellow indicates some deterioration in patient condition, and red prompts clinicians to log on immediately to see the problem and decide a course of action. When appropriate, a rapid response team assesses the patient, and expedites a transfer or other action. This strategy has led to a reduction in codes [requesting data] • Streamlined all major processes, e.g., order entry process was reduced from 30 steps to six steps when automated • Admission history database includes red/yellow/green dots to prompt nurses to complete every protocol, in real time • Medication processes have been streamlined, and evidence-based medicine alerts and reminders are in place. They have avoided 117,400 potential medication errors using barcoding • Reductions in illegible orders and time spent deciphering them • Duplicate tests have been reduced • Communication among providers has been enhanced • Nurse time on direct patient care increased from 42.1% before EHR to 51.4% after EHR • The hospital attributes a reduction in the mortality ratio (actual mortalities over expected mortalities) from 2009 to 2010 to 2011, and improvement in CMS quality measures, that it attributes to the EHR

VA CENTRAL IOWA HEALTH CARE SYSTEM	
Description	<ul style="list-style-type: none"> • VA Central Iowa Health Care is a health care system component of the Department of Veterans Affairs. It is a teaching hospital in Des Moines with 39 inpatient beds, and 140 beds in an extended care unit. It is part of the national system providing comprehensive services to veterans. It operates Community Based Outpatient Clinics (CBOCs) in Mason City, Fort Dodge, Knoxville, Marshalltown, and Carroll • The medical center provides acute and specialized medical and surgical services, residential outpatient treatment programs in substance abuse and post-traumatic stress disorder, a full range of mental health and long-term care services, and subacute and restorative rehabilitation services
EHR system	<ul style="list-style-type: none"> • VHA-developed product
Impetus for EHR	<ul style="list-style-type: none"> • The decision was made long ago, before interviewees were involved. They believe that the impetus was to improve communication between disciplines within the system • No products commercially available at the time, so the VA developed a system called the Computerized Patient Record System (CPRS). The underlying platform is called VISTA, developed in the late 1980s • EHR is comprehensive, spanning VA providers across the U.S. and allowing system integration • The VA still builds new modules as it identifies new needs and continues to customize, including adding checklists; recently added capacity to share images across services lines and pharmacy barcoding • The next step will be to switch from fully integrated EHR to “plug and play” model to allow modification and updates to components more readily
Interconnectivity	<ul style="list-style-type: none"> • The ability for EHR communication between VA and non-VA providers is limited. The VA EHR is available to anyone who wants a copy, but there has not been demand • The VA and the Department of Defense are piloting a joint medical record in some locations (not Iowa)
Examples of EHR-facilitated quality improvements	<ul style="list-style-type: none"> • Specific quality measures were built into the system, and reminders to clinicians were added to help them achieve better quality (e.g., tobacco screening, HIV testing, diabetic screening, medication reconciliation) • The VA takes a research/evidence-based care approach to analyzing data to identify the best practices that achieve good outcomes. They also built reports (either called “primary care almanac” or “health factors”) that help clinicians sort patients and identify those whose values on labs and clinical indicators are out of range, showing information longitudinally and at a point in time. Physicians review these indicators for their own patients, but service lines and the quality departments also receive and review them • VA intends to move toward providing more care where the veteran is—including in their homes and at community outpatient clinics—and the EHR will be part of these efforts

YALE–NEW HAVEN HOSPITAL	
Description	<ul style="list-style-type: none"> • Yale–New Haven Hospital (YNHH) is a nonprofit, 966 bed tertiary care facility in New Haven, Connecticut • It is the primary teaching hospital for Yale School of Medicine, and the flagship of the Yale–New Haven Health System, which includes three hospitals, with 1,597 beds, providing 1.2 million outpatient visits a year
EHR system	<ul style="list-style-type: none"> • Inpatient: Allscripts (formerly Eclipsys) and ambulatory: GE Centricity, with plans to shift to Epic
Impetus for EHR	<ul style="list-style-type: none"> • In 1990, YNHH made the decision to adopt an EHR. It was not then a priority to integrate information across the hospital and medical school • Recently, physicians at the hospital have been interested in getting more outpatient information, particularly for heavy users of health care • Because the system has one flagship hospital, the hospital’s leadership was highly involved in the decision process
Interconnectivity	<ul style="list-style-type: none"> • A few clinics use a different EHR, but integration between inpatient and outpatient settings was not previously a goal • Outpatient records would sometimes be available in a scanned, but not searchable, format • Doctors can view lab results and notes remotely
Examples of EHR-facilitated quality improvements	<ul style="list-style-type: none"> • YNHH strongly emphasizes evidence-based tools for clinicians. About 80% of ordering is guided, with prompts and questions to help clinicians pick the best drug or treatment protocol. YNHH has a high degree of buy-in for clinical guidelines and direction using order sets based on evidence • A popular feature is the tracking board used by inpatient units to share information, such as new orders posted and discharge status • YNHH has a data repository, and uses VIPER software for quality reporting. A corporate-level dashboard includes about 60 measures, and staff have their own metrics • YNHH identifies areas for quality improvement by reviewing data for irregularities. For example, when data indicated underuse of heparin, a process change in how heparin patients are monitored encouraged physicians to order the right level of anticoagulant. Following the process change, correct dosing increased from 60% to 95% • For insulin dosing, the availability of more accurate dosing information in the EHR than physicians are able to remember has led to improvement • Physicians are able to review and manage patient panels better, for example looking at all their diabetic patients to see who needs attention • Choice of antibiotics has improved because a set of questions guides prescribing decisions. • Legibility improvement reduces errors

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