Implementing an Ambulatory e-Prescribing System: Strategies Employed and Lessons Learned to Minimize Unintended Consequences

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Abstract

Electronic health records are thought to improve quality of care; computerized provider order entry (CPOE) systems are believed to reduce medication errors. Yet, research suggests that implementation of new technologies revises existing sociotechnical systems and introduces unpredicted and unintended consequences, including the generation of new types of errors. We narrate development and implementation of a CPOE system—specifically a homegrown, e-prescribing system—in a community-based, integrated health care system. We describe the strategies used and lessons learned that enabled successful adoption: buy-in starts at the top of the organization; ongoing communication is key; a team-oriented culture is critical to success; iterative implementation is a useful strategy; ongoing and readily accessible training is necessary; involvement of clinicians achieves buy-in and contributes to ongoing improvements; and workflow redesign is an integral facet of implementation. These strategies and lessons were used to minimize unintended consequences and to maximize the potential of e-prescribing technology to improve medication safety.

Introduction

A recent systematic review of the impact of health information technology (HIT) on the quality of medical care revealed that HIT interventions—primarily electronic health records (EHRs)—improve quality by improving medication safety, increasing adherence to guidelines, and providing tools to enhance disease surveillance.[1] Most research that documents these benefits describes a few systems implemented in the inpatient setting, primarily in academic medical centers.[2, 3, 4, 5, 6, 7] Less work has been conducted in the ambulatory setting, where volumes and complexities are greater.[8] Much of this work describes the benefits of computerized provider order entry (CPOE) systems, which have been studied as a proxy for EHRs.[9]

The limited body of literature describing the benefits of EHRs reflects the fact that in the United States, adoption of EHRs has been slow in both inpatient and ambulatory settings.[10] The perceived barriers are many: increased workload for clinicians; unfavorable impact on workflow and communications; negative emotions; changes in power structures; and importantly, generation of new kinds of errors.[10, 11, 12, 13] Research suggests that the implementation of new technologies revises existing sociotechnical systems, creating behavior changes that cannot be fully predicted from the individual social or technical components.[14] These changes result in unintended consequences, called latent or silent errors. Indeed, the social organization of medical work is now widely recognized as an important aspect to consider when designing and implementing HIT solutions to improve health care.[14]

Use of a CPOE System to Improve Medication Safety

The Everett Clinic prioritized implementation of a CPOE system, specifically an e-prescribing system, primarily to improve medication safety by reducing medication errors. Further, embracing the philosophy that unintended consequences can originate from unexpected sources—such as system design, implementation strategies, or the organizational culture associated therewith—The Everett Clinic paid careful attention to these overarching aspects during e-prescribing implementation and documented the strategies and lessons learned. In this report, we provide a chronologic narrative of e-prescribing implementation, weaving throughout a description of the strategies that enabled successful implementation. We also present a comprehensive list of lessons learned and highlight the importance of these lessons in minimizing unintended consequences and improving medication safety. Separately, we have conducted quantitative evaluations of the impact of the e-prescribing system on medication errors and on the time-intensity of e-prescribing. The results of these studies are being reported separately.

Setting

Founded in 1924, The Everett Clinic (the Clinic) is a vertically integrated, multispecialty physician group practice that provides comprehensive, community-wide health care for the northern Puget Sound area. Over 250 physician-owners deliver care to 225,000 patients in 14 ambulatory locations. Facilities include eight urgent care clinics, two outpatient surgery centers, comprehensive laboratory services, an advanced imaging center, four retail pharmacies, and a cancer center. A hospitalist team from the Clinic admits to the single hospital in the local market and provides continuity of care between the ambulatory and inpatient settings.

The culture of the Clinic includes a stable leadership team that embraces a culture of safety, efficiency, and continuous quality improvement of clinical care. A high priority is implementing programs aligned with the six aims for improving health care in the 21st century, as promulgated by the Institute of Medicine, which include effective use of information technology (IT) and re-engineering care processes.[15]

The Clinic maintains a full array of HIT services through its wholly owned IT subsidiary. From 1995 through 2007, these IT professionals were responsible for developing and implementing the Clinic's homegrown EHR and e-prescribing system. In late 2006, in the interest of long-term sustainability of the EHR, the Clinic's board of directors made the deliberate decision to transition to a vendor-purchased EHR, purchasing Epic® (Epic Systems Corporation, Verona, WI) in 2007. The Clinic is now in the process of customizing the Epic® system with features of its homegrown system, particularly its e-prescribing system. The strategies used and lessons learned from implementing the Clinic's homegrown systems are proving useful in the Epic® rollout.

Developing and Implementing the Homegrown e-Prescribing System

Context

At the outset, a physician advisory board was appointed to guide implementation of clinical IT initiatives. The homegrown EHR was launched in 1995, with additional features and functionality added over time (Table 1).[16]

Table 1. Timeline for the development and implementation of the electronic health record

Year	Activity or feature developed/implemented
1995 - 1997	• IT subsidiary formed • Intranet developed • Practice management system converted to Web platform
1997 - 1998	• Development of comprehensive, homegrown EHR prioritized by leadership • Transcription system for chart notes and radiology reports
1999	• Patient profile added to transcription system: demographics, problem list, surgeries, medication list, allergies
2000	• Laboratory system
2000 - 2002	• Integration of practice management, transcription and laboratory systems create true EHR • Features added: physician schedules, health maintenance information, immunizations, reference laboratory reports, radiology images, pathology reports, and electrocardiograms • Links added for access to patients' insurance plans, patient educational materials, drug information and disease management guidelines, and patient registry information • Security system developed: single sign-on required; electronic signatures added • Hospital admit and discharge summaries; hospital images • Remote access from off campus
2002	• E-prescribing module prioritized, with the goal of improving medication safety
2003 - 2005	• Development and rollout of e-prescribing system (see text)

EHR = electronic health record; IT = information technology

Several times during these years, leadership conducted market evaluations of commercially available EHR products, but at each juncture, they found that available systems were expensive, cumbersome, and not well-accepted by users, and they were thought to decrease workflow and productivity. Thus, until 2006, the Clinic returned to development of their homegrown system. Throughout the development process, the developers paid close attention to meeting national standards as codified (e.g., Health Level 7[17]), and to maintaining compliance with requirements of the Health Insurance Portability and Accountability Act (HIPAA).[18]

Since its inception, a detailed log has been kept of every user transaction, which has provided a rich source of data for making improvements in safety and quality.

Lessons learned. The advisory board is of pivotal importance in setting priorities in an organization where competing priorities are the norm, for example, making investment decisions and ensuring that projects stay on track.

E-Prescribing Development and Testing

The e-prescribing module was prioritized in 2002. The Clinic purchased the Multum® drug database (Cerner Multum, Inc., Denver, CO) and, using it as the backbone, spent several months developing the e-prescribing module. Two clinical pharmacists led the effort on the clinical side, working closely with the IT professionals. Their task was to ensure that the drug database used to populate the module was accurate and relevant and that screens were easy to use and involved minimal manipulation. The resulting e-prescribing system is Web-based and includes point-and-click functionality. Medications, strengths, doses, and directions are selected from drop-down menus. When a prescription is written electronically, it is saved on the mainframe computer and can be printed and handed to the patient or automatically faxed (auto-faxed) to a retail pharmacy of the patient's choosing. (Prescribing software does not currently allow for full electronic transfer to retail pharmacy order entry software.) The printed prescription is maintained by the retail pharmacy as part of the patient record.

The Clinic developed an e-prescribing system that includes basic clinical decision support (CDS) features,[19] reasoning that it was best to start simply and to not overwhelm users with too much information. Features included from the outset were basic dosing guidance, formulary decision support, and duplicate therapy checking. Fearful of causing "alert fatigue"[20] due to the display of clinically insignificant alerts, the conscious decision was made to delay implementation of drug-allergy and drug-drug interaction checking.

During development, Clinic leadership educated all prescribers and staff about the upcoming change from paper-based to electronic prescribing. A mascot representing the change was designed and introduced to facilitate buy-in: a "superhero" named "MedMan," short for Medication Management. MedMan was used to convey the important information that one of the primary goals of the e-prescribing system was to improve medication safety. The term proved quite popular among physicians and staff, and MedMan became synonymous with the e-prescribing system. One clinic was selected to pilot the e-prescribing module; this was an internal medicine site with six prescribers who were enthusiastic about the prospect. Training was provided, and the module went live on July 1, 2003 (Day 0).

Lessons learned. Each feature added must be easy to use and require minimum effort to navigate. Quality and efficiency must be built in with every step. Extensive user interviewing and testing are necessary—not just feature-specific testing but also testing of component integration. Testing becomes more complex as the system matures, and adequate time must be allocated. Perception differs among users, and testing efforts should accommodate as many user styles as possible. Feedback should be encouraged from all, incorporated, and used to facilitate system improvements, enhancements, and error corrections. A helpful tactic is to decide what is "mission critical" with each new release, withholding launch until these elements are perfected.

Training and Implementation

Five months after Day 0, the average number of prescriptions leaving the internal medicine site weekly was 625, a small number but a sound start. The early success story at the pilot clinic was championed at site-specific, clinic-wide, and board of directors meetings. Implementation at other sites proceeded according to a strategic plan, created based on the culture and provider mix at each site; primary care sites preceded specialty sites. Site-specific launch meetings were provided in the group setting; buy-in was achieved by providing advance education. The old adage, “Tell them what you are going to tell them; tell them; tell them what you told them,” held true for implementation.

Clinical pharmacists and IT professionals provided training, one on one, at the point of care, with a minimum of two subsequent “check-ins.” Training continued on an as-needed, just-in-time basis, with the IT professionals and the clinical pharmacists serving as the “help desk,” monitoring backend utilization, and responding to telephone calls and e-mails about software/ hardware or clinical issues, respectively. Training during implementation was divided into two phases: authorizing prescription refills, followed by writing new prescriptions. Use of the system was encouraged but remained voluntary.

The speed of adoption varied widely. Previous computer experience ranged from novice to expert and from positive to negative. Each factor influenced adoption beliefs. Early adopters served as trainers. Late adopters were encouraged by addressing their perceived barriers in one-on-one meetings. Although prescribers at one site voiced strong opposition to e-prescribing, leadership listened to their concerns, assisted them in realizing the benefits of the system, and proceeded with implementation. Newly hired prescribers were expected to use the system from the day they joined the practice.

Eighteen months after Day 0, 110 prescribers were using the e-prescribing system for at least some of their prescribing, resulting in over 6,000 e-prescriptions transmitted to pharmacies, weekly; 24 months after Day 0, 200 of the 225 prescribers were prescribing electronically. The final site to go live was the ophthalmology clinic, which went live 51 months after Day 0. Maintenance was provided, and enhancements were made throughout this time, with vigilant monitoring and constant attention paid to improvements. Over time, lists of prescribers’ favorite medications and drug laboratory checks were added. These provided additional medication safety features and proved popular. A list of over 225 retail pharmacies to which prescriptions could be auto-faxed was added. At present 5,000 new e-prescriptions leave the Clinic daily, 95 percent of the total number written.

Lessons learned. Including IT and clinical personnel as members of testing and implementation teams results in a more robust product, facilitates buy-in, and helps streamline rollout. Key to our success was the iterative process by which new features were introduced and implemented. Coupled with this was the deliberate decision to slow implementation until users became accustomed to new features already released. This approach prevented widespread resistance or even potential rebellion, and it allowed the necessary time to make small course adjustments without abandoning the entire project.

Gradual development and implementation kept the system affordable and prevented substantive reductions in productivity during rollout. Sharing with clinicians the preliminary results of our quantitative evaluations—which have revealed a reduction in medication error rates and the time-neutrality of e-prescribing—further facilitated buy-in.

Training provided “just in time” and 24/7 minimized user frustration and provided opportunities to educate users about appropriate use. In vigilantly monitoring the backend of the system, the pharmacists found many opportunities for clarification, retraining, and identification of database or programming errors, thus minimizing the occurrence of prescription-related medication errors. The trainers also found that users adopt technology at widely varying rates; and although users might not ask questions, full understanding could not be inferred by the lack of questions. Demonstrations were highly effective; understanding was assured when the user could repeat the demonstration using the mouse him/herself.

Using early adopters as trainers was well received. Peer pressure created an incentive for adoption. Negative first impressions expressed by reluctant users were frequently overcome with acknowledgment of their concerns and familiarity of use. One year after implementation, the group that was initially resistant admitted to liking the system and to seeing the benefits. The new physician-owners have embraced the use of the system from the moment they joined the practice.

When training, the team realized that physicians have never been trained to handwrite prescriptions. Many prescribers were unfamiliar with units of measurement used to accurately prescribe medications (e.g., teaspoons vs. milliliters). A review of the necessary components was undertaken prior to transitioning to e-prescribing. This greatly helped ease the transition from paper to electronic prescribing and reinforced best prescribing practices to maximize medication safety.

Network

E-prescribing adoption proceeded more quickly than leadership had anticipated. An unanticipated problem was that the IT infrastructure (i.e., facsimile servers, stability, and redundancy) was unable to keep up with adoption. As prescription volume increased, network speed to facilitate auto-faxing became important. The Clinic engendered the cooperation of the local utility company to solve the problem of the long “fax queue” of prescriptions to dispensing pharmacies. Several receiving retail pharmacies also agreed to add additional fax machines to ease the backlog. Development was sometimes postponed to allow time for more robust infrastructure development. System upgrades caused slowdowns, of which clinicians were intolerant. One system upgrade caused speed-related user complaints to increase from 10 to 150 calls per week.

Lessons learned. Sufficient up-front investment in the infrastructure is necessary to support rapid adoption. Speed is dictated by the type of cable used by the local utility company; fiber optic cable is faster than microwave. Keeping the network functioning well requires constant vigilance by IT professionals. Also important is the development of a sound plan that can be activated when the system becomes unavailable. Downtime procedures should include processes for patient registration, patient charting, and handwritten prescribing and for incorporating these into the EHR when it again becomes functional.

Retail Pharmacies

At the time of implementation, retail pharmacies that served clinic patients were not accustomed to receiving electronically written prescriptions via auto-fax. Leadership educated members of the Washington State Board of Pharmacy regarding the benefits of e-prescribing and walked board members through the process of prescription verification. Rules for electronically transmitting prescriptions were developed and approved by the State Board prior to launch. Prescription legitimacy is now verified by setting both the sending and receiving fax machines to display the corresponding telephone numbers.

Lessons learned. Educational efforts conducted by the Clinic for retail pharmacists and State Board members facilitated the e-prescribing process. This, in turn, improved patient care by decreasing wait times at the pharmacy and by eliminating a step wherein drug diversion could occur. It also provided an opportunity to educate these important stakeholders about the realities of functioning in a medical group and about the emerging trend of e-prescribing.

Clinic Workflow

The most challenging issues involved the hardware and platform on which the EHR and e-prescribing module were housed. Prior to July 2003, users accessed the EHR via desktop computer terminals located in each prescriber's office and at centrally located workstations throughout the clinics. However, the Clinic's goal was to provide each prescriber with his/her own laptop computer and to have all users access the EHR using a clinic-wide wireless network.

Thus, in July 2003, each prescriber at the pilot site was provided with a laptop, with the intent that it would serve as a personal mobile device they could take into the examination room during the day and home at night. The initial strategy for e-prescribing (software) rollout also included the rollout of hardware and networking capabilities. Sites were grouped into three categories for ordered implementation: (1) refills partially adopted/wired desktops, (2) refills partially adopted/wireless laptops, and (3) refills fully adopted/wireless laptops. In the midst of this rollout, the IT professionals realized that the goal of functioning entirely on a wireless network was not feasible in the near term, due to issues of stability, reliability, and robustness. Leadership spent several months exploring solutions, eventually abandoning wireless implementation in its entirety, in favor of hardwiring all 505 examination rooms with desktop computers.

By early 2006, the Clinic was exploring designs for hardwiring examination rooms, with a focus on workflow; two options that were seriously considered were mobile carts and wall mounted systems with flexible arms; the latter option eventually was adopted. Mock examination rooms were configured; users were invited to try them out and provide feedback. A walkthrough was conducted at all 505 examination rooms. Space issues were paramount, and configuration solutions were sometimes unique to each examination room; retrofitting was sometimes necessary. A Web site was created through which stakeholders could express their views and make recommendations. A list of Frequently Asked Questions (FAQs) was posted.

Because of e-prescribing implementation and installation of desktop computers in examination rooms, clinical workflow was re-engineered to standardize processes, increase efficiencies, and integrate care among clinicians and staff. A standard rooming process was adopted, empowering medical assistants to perform several tasks intended to improve care. In addition to rooming each patient and taking vital signs, medical assistants now schedule mammograms and colonoscopies, conduct incentive spirometry checks, prepare laboratory orders, and prompt prescribers about disease management reminders.

As workflow changed, the requirement for increased competence in managing medications became apparent. The clinical pharmacists created an educational module targeted toward frontline clinic staff, which described the top 200 medications that receive refill requests and prompt medication questions from patients. The module includes a crosswalk between brand and generic names, drug indications, and a short list of drug-specific monitoring parameters. The program is delivered through a PowerPoint® presentation, a 20-page handout, and a quiz. Separately, registered nurses, who have historically been required to contact physicians directly to obtain approval for prescription refill requests or to find answers to patient-specific questions, can now send an e-mail on the Clinic intranet system, alerting the prescriber to the situation and the desired outcome. The use of these e-mails, called “patient encounter forms” (PEFs), has streamlined exchanges between physicians and nurses, allowing each professional to prioritize their daily tasks as they see best.

Lessons learned. Determining the adequacy of wireless network speed installations was sometimes delayed for 2 to 3 weeks after installation. Ultimately, it was the physical plant infrastructure that prevented installation of a reliable wireless network.

With hardwiring, Clinic leadership realized early on that re-engineering workflow was necessary and that it would provide an opportunity to increase efficiencies and promote standardization, both of which are integral to successful implementation. Advance preparation for workflow redesign paid off with a smoother transition. Mockups were helpful in achieving buy-in and preventing later reworking. With the decision to install desktops came the realization that the physical area of the examination room of the future might need to be larger to accommodate new technologies and enable efficient workflow. Standards that promote handoffs from staff to provider and that integrate data entry and access among all users were particularly helpful in easing the providers’ burden. Asynchronous communication between nurses and physicians has increased efficiencies.

Transitioning from one HIT solution to another (i.e., laptop to desktop) proved challenging. Users immediately compared the two. Anticipating this dynamic would be helpful, the team created a list of benefits of the more recent initiative and shared these when resistance surfaced.

Using a laptop is vastly different from using an examination room desktop, in that the former is used by a single individual, while the latter may be shared by multiple users. With the latter, accommodations were made for information sharing, moving between files, and user verification, as workflow demanded. A cultural shift from “my exam room” to the “standard exam room” was noted. A spike in e-prescription volume was also noted after desktop installation.

Patients have been overwhelmingly positive about the availability of the EHR in the examination room and enjoy looking at their data with the physician. Concerns that the provider no longer faces the patient have not materialized.

Security

Identifying a feasible solution to provide an adequate security system was another challenge. With busy clinicians and staff entering and exiting examination rooms upwards of 20 times daily, it was critical to adopt a system that would protect patient privacy and allow quick access, while minimally impeding workflow. The Clinic adopted a system that first requires each user to login each morning. This initial login is followed by an unlimited number of secondary logins, using the combination of a swipe card and a short, user-specific password. In preparing for a patient visit, the medical assistant slides the card into a reader and receives access to screens appropriate for his/her level of employment. When the card is removed, the computer is secured and left in a mode that reverts to the queued patient when the provider swipes his/her card.

Lessons learned. Security issues were thought through from both the hardware (device) and software (application) perspectives. Finding a workable security solution took several months. In the end, the use of context-switching and logon/logoff cards was found to be an effective way to both secure work stations and switch between users.

Transitioning to a Vendor-Based Electronic Health Record

Notwithstanding the success of their homegrown EHR and e-prescribing system, adding additional technology began to stress and crash the homegrown system. Moreover, Clinic leadership and the IT professionals kept a pulse on developments in the field of commercially developed EHRs. Initially, the idea of transitioning to a vendor-purchased system was controversial amongst the physician-owners, but by 2006, the market had reached a level of maturity that made such discussions worthwhile.

The rationale for switching was that a commercial product, supported by resources sufficient to sustain ongoing development and evolution, would better position the Clinic for long-term success. It would also improve the safety and quality of care by providing more robust and integrated clinical outcomes data. The board of directors launched an educational campaign that described the benefits and risks of purchasing such an EHR. A Web-based dialogue was initiated. After months of thoughtful discussion, physician shareholders voted to purchase the Epic® system (Medi-Span®, Wolters Kluwer Health, Conshohocken, PA). Additional IT professionals were hired, and customization took place during 2007, with rollout anticipated to take up to 2 years.

Lessons learned. Lessons learned from the homegrown era are being applied. Once again, a clinic-wide dialogue to facilitate buy-in was critical to move the project forward. A pilot site transitioned first. “Super-users” have been called on to assist in implementation.

Customizing Epic®

From the e-prescribing perspective, the Clinic is customizing the Epic® product to incorporate features of its homegrown system that optimize medication use and safety. Team members have painstakingly mapped drugs from Multum® and the homegrown system to the drug database used by the Epic® system (Medi-Span®, Wolters Kluwer Health, Conshohocken, PA), as each database utilizes differing forms of drugs and dosage notations. Corrections are shared with the vendors when discrepancies are found. The clinicians on the team focus on every detail, dosage form, package size, and quantity dispensed, while the IT professionals focus on speed and reliability. The goal is 100 percent accuracy when it comes to prescribing medications; any standard less than this can predispose to patient harm.

The Clinic is creating robust preference lists to improve the clinician-user experience. The focus is on customizing advanced level CDS programming, limiting machine-actionable alerts to only those that are of clinical significance. The Pharmacy and Therapeutics Committee is overseeing the customization of drug-allergy and drug-drug interaction alerts. Epic® uses a 12-level alert system for allergies. The Clinic has decided to "fire" only a portion of these.

Similarly, the team has learned that the classification systems for drug-drug interactions used in the databases provided by the three vendors in the marketplace (Multum, Medi-Span, and First Databank®, San Bruno, CA) are different from the classification systems used in popular drug-drug interaction literature[21]; the former use a three-category system, and the latter uses a five-category system. Mapping these systems from Multum to Medi-Span has been challenging. E-prescribing will become mandatory when the Epic® system is totally implemented and fully functional.

Lessons learned. Customization of the drug database and CDS alerts has been a tedious and time-consuming task. The lack of standardization of classification systems used by vendors of the commercial drug databases has been a finding that was both unexpected and of some concern. The differing, yet complementary, areas of expertise of both clinicians and IT professionals are necessary to deliver CDS alerts that will serve as intended to maximize patient safety. Overall, the team has been enlightened about the amount of work still needed in the field, before CDS alerts can provide the potential benefits for which they are intended.

Discussion

The Everett Clinic has accrued 12 years of experience in developing and implementing an EHR. The major lessons learned are that buy-in starts at the top of the organization; ongoing two-way communication is key; a team-oriented organizational culture is critical to success; iterative implementation is an effective strategy; ongoing and readily accessible training is necessary; involvement of clinicians in every facet of development achieves buy-in and contributes to improvements; and workflow redesign is an integral facet of EHR implementation. A more detailed summary of these lessons appears in Table 2.

The risk of unintended consequences with implementation of EHRs and CPOE systems is great. One expert panel has described nine categories of adverse consequences:[13]

1. More work for clinicians.
2. Unfavorable workflow.
3. Neverending system demands.
4. Problems related to paper persistence.
5. Communication difficulties.
6. Negative emotions.
7. Generation of new kinds of errors.
8. Changes in the power structure.
9. Overdependence on technology.

Table 2. Summary of lessons learned

Category	Lesson learned
Context	• Physician advisory board sets priorities, keeps project on track
System development & testing	• Each added feature should be tested for ease of use • Extensive user interviewing and testing is helpful • Adequate time must be allowed for testing • Both feature-specific and component integration testing are necessary • Feedback from users should be encouraged and used to make improvements and corrections • Launch only features that have been perfected
Training & implementation	• Involving clinical and IT personnel results in more robust product facilitates buy-in, streamlines rollout • Iterative rollout and introduction of new features enhances buy-in, keeps system affordable, prevents reduction in productivity • Training provided one-on-one at point of care, just in time, and 24/7 minimizes frustration; provides opportunities to educate about appropriate use; identifies corrections; and allows further improvements to minimize potential for medication errors • Demonstrations are effective; understanding is assured when user can repeat process • Early adopters make good trainers • Training provides opportunity to reinforce “best practice” techniques for “writing” prescriptions
Network	• Sufficient upfront investment is necessary to support rapid adoption • Fiber-optic cable is faster than microwave • Involving utility company facilitates auto-faxing • System maintenance includes vigilant monitoring and readiness of downtime procedures
Retail pharmacies	• Educating about auto-faxing is paramount for buy-in of this group of external stakeholders
Clinic workflow (transition from wireless laptop to hardwired desktop computers in exam rooms)	• Physical plant infrastructure can prevent adoption of wireless network • Re-engineering workflow is critical to success of this transition • Advance preparation in countering resistance is helpful • Standardizing transitions between staff and providers eases provider burden, creates culture of “shared” examination room • Patients are positive about having computer in exam room
Security	• Approach from hardware (device) and software (application) perspectives • Context-switching log on/log off cards are effective

Table 2. Summary of lessons learned (continued)

Category	Lesson learned
Transitioning to Epic®	• Reaffirm importance of ongoing, two-way, and clinic-wide communication • Customization of drug databases and CDS alerts is tedious • Lack of standardization of vendor-created classification systems creates complexities • Efforts of clinicians and programmers are essential to success of CDS alerts • Much work remains to be done in field of CDS alert development before full potential of CDS alerts can be realized to improve safety and quality of care

Importantly, this panel suggested that CDS features introduce many of these unintended consequences.

Others investigators[22] framed these same concerns as aspects that must be addressed in order to achieve successful implementation and to avoid unintended consequences. They found that organizational issues—such as collaboration, culture, and control—were instrumental in successful adoption. They also noted that clinical and professional issues—such as individual or specialty customization—were important in achieving clinician-user buy-in, and that technical and HIT implementation issues included the need to continually modify the system, conduct usability testing, provide adequate training and support, and ensure that network speed made using the EHR time-neutral. Finally, they found that information needed to be organized in a way that would make intuitive sense to clinicians, rather than to programmers. These characteristics were incorporated into a consensus statement that described considerations for successful CPOE implementation.[10] To avoid the unintended consequences related to medication use, The Everett Clinic has focused on these same issues in developing their e-prescribing system.

The Everett Clinic's experience is unique in that it operates from the perspective of having implemented both a homegrown and now a vendor-purchased EHR. In the former, it is similar to inpatient, academic institutions that have developed their own systems and used them with much success.[2, 3, 4, 5, 6, 7] In the latter, it is similar to other community-based health care systems not affiliated with academic centers, although these systems are more likely to purchase their EHRs without having first developed their own.

For several reasons, we believe the Clinic's experiences with its homegrown system can be generalized to other community-based health care systems preparing to implement EHRs. Many of the barriers and challenges identified by health care systems that are implementing commercially available systems have also been addressed and overcome by The Everett Clinic: identifying core functionalities, conceptualizing the impact of the EHR on workflow, conducting a market analysis, conducting field tests prior to going live, ensuring a functional network, developing software that is user-friendly, and addressing security issues. That the Clinic is applying the lessons learned in all aspects of implementation to Epic® customization, particularly with e-prescribing, further attests to the generalizability of our lessons learned.

Conclusion

Implementation of EHRs, and particularly CPOE systems, is fraught with the risk of introducing unintended consequences into the clinical environment. The identification of strategies that can aid implementation and minimize unintended consequences is important to realize the full potential of HIT solutions in improving patient care. The Everett Clinic utilized several strategies that enabled successful implementation of their homegrown e-prescribing system and concurrently learned valuable lessons. As EHRs become more widely implemented, applying these strategies and lessons to system implementation can minimize unintended consequences and maximize the quality and safety of patient care.

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