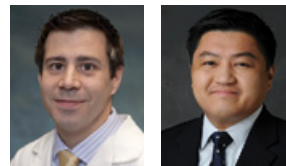# Online Relationship

Electronic Health Records for Patient Safety

LESSON 12

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OBJECTIVES

On completion of this lesson, you should be able to:

1. Provide an overview of informatics concepts as they pertain to the electronic health record (EHR).
2. Identify specific interface design concepts that can affect patient safety.
3. Describe best practices for interface design, information display, and management of the EHR.
4. Describe best practices for end-user customization of the EHR interface and workflows.

FROM THE EM MODEL

20.0   Other Core Competencies of the Practice of Emergency Medicine
    20.4   Systems-Based Practice
        20.4.1.3   Electronic Health Record

CRITICAL DECISIONS

- What steps can be taken to protect patient privacy when using EHRs?
- How can emergency physicians optimize the use of electronic tracking boards?
- What pitfalls should be considered when using EHR alerts?
- How can errors be minimized when entering orders, viewing results, and administering medications?
- How can clinical decision support tools improve patient safety?
- What steps are required for the proper development and maintenance of EHRs?
- How can clinicians leverage the Health Information Exchange to provide safer patient care?
- What is the most effective way to provide aftercare instructions?

Electronic health records (EHRs) are complex because medical care itself is complex. To make effective use of data and knowledge, EHR implementation and maintenance must be continuously improved upon both within the clinical environment and throughout the organization. Workflows must be completely mapped and optimized, considering new efficiencies made possible by the system. A well-designed EHR can not only simplify processes, gather and summarize data, and improve communication, but can also be a partner in maximizing patient safety and providing effective care.

CASE PRESENTATIONS

■ CASE ONE

After working several consecutive shifts, an emergency physician takes home his paper notes, which he uses to track patients in conjunction with the EHR. The paper notes contain the names, medical record numbers, and chief complaints of two discharged patients he saw over the last few shifts. Planning to follow up with them later, he'd also scribbled down the phone numbers of the patients.

The first patient was a well-appearing elderly man who presented with an influenza-like syndrome. He had one episode of vomiting, but his laboratory results were normal and he improved after treatment. The second patient was a well-appearing nonpregnant woman with fever, nausea, back pain, and dysuria who was diagnosed with pyelonephritis.

When the physician calls the patients several days later, he is reassured to find that they are both improving. He is alarmed, however, to discover that he misplaced the paper notes containing their patient health information.

■ CASE TWO

A 38-year-old woman presents with a 2-day history of fever, cough, and shortness of breath. She has no past medical or surgical history but is allergic to penicillin. Her vital signs are heart rate 122, temperature 38°C (100.4°F), and oxygen saturation 92% on room air. Her lung sounds are decreased in the left lower chest. Pneumonia is confirmed by chest x-ray, which shows a left lower lobe infiltrate.

The emergency clinician decides to treat her with intravenous (IV) ceftriaxone and azithromycin. During the computerized order entry process, an alert indicating an allergy to penicillin pops up, but the physician bypasses it with a single click. The nurse administers the medication after using a knowledge-based bar coding system for medication administration. A few minutes later, the patient develops a rash and has difficulty breathing.

■ CASE THREE

A 27-year-old man presents with abdominal pain and requests pain medication. Given that he has been maintained on a long-acting opiate for chronic pain after a gunshot wound, the physician elects to order hydromorphone. She clicks on a pre-composed order for "hydromorphone 1 mg IV q 15 min PRN severe pain x 2 doses" from her list of saved orders, a prescription she has placed many times in accordance with department protocol, and signs it. Shortly afterward, the nurse questions if she meant to order 68.7 mg of hydromorphone, as that seems like an unusually high dose, even for someone tolerant to opiates. The nurse notes that the dosage was verified by the pharmacy.

The adage "If you've seen one EHR system, you've seen one EHR system" is unfortunately true. Most vendors offer a suite of software solutions for managing patient care and various business functions, but most of those tools are shipped to the customer in an unusable default state. Each organization is required to configure, customize, integrate, and extend the systems to their needs and practices under varying levels of vendor support and guidance.

And therein lies the rub. No industry must grapple with as many nuanced issues and varied approaches to "standard work" as health care. Few, if any, best practices apply to the entire house of medicine, yet local integrations and customizations can result in unique errors foreign to a paper system.[1] However, properly designed, properly implemented, and properly maintained health information technology (HIT) can prevent or mitigate many of these mistakes.

As noted by the National Academies of Sciences, Engineering, and Medicine, Health and Medicine Division (HMD) (formerly the Institute of Medicine), "Health IT is not a single product; it encompasses a technical system of computers and software that operates in the context of a larger sociotechnical system — a collection of hardware and software working in concert within an organization that includes people, processes, and technology."[2] Furthermore, the HMD views patient safety not as a property of the software, but as a result of how people use the system.[3]

Current versions of EHRs and other health ITs have not generally lived up to the promise of enabling safer, more efficient, and less costly care.[4] Many of these software applications were designed to assist with billing and related business operations and were later transformed for direct clinical use as the market evolved.[5] As such, the IT landscape is littered with systems ill-suited to the unique nature of clinical medicine, which is defined by highly complex cognitive workflows that require multiple participants to carry out tasks under time pressure amidst constant interruptions.[6] This mismatch between the rigid workflow requirements of the EHR and the fluid nature of clinical care leads to cognitive overload, data entry and retrieval errors, communication errors, and a reduction of the patient to a series of seemingly unconnected data points.

According to the HMD, "Continuing to use paper records can place patients at unnecessary risk for harm and substantially constrain the country's ability to reform health care."[7] An EHR allows a health care system to overcome the limitations of the paper chart — availability, simultaneous access, organization, and legibility. It must be recognized, however, that even when properly built to optimal efficiency, the use of an EHR for order entry and documentation clearly requires more clinician time spent in front of a computer.

This investment must return great dividends to be cost-effective. If

properly implemented, the nation's health information infrastructure is projected to save from $142 to $371 billion annually (out of $3.2 trillion total expenditures).[8,9] A recent study showed an average of 9.6% savings per hospital admission using advanced EHRs.[10] These savings depend on effective information exchange to ensure that complete, relevant medical information for each patient is immediately available and that providers are able to use the information constructively.

Despite all the potential benefits of EHRs, the adoption of health IT has been plagued by poorly aligned incentives. Patients and payers are the primary beneficiaries of cost savings and safety enhancements, but providers and health systems are paying with both actual costs and decreased productivity, increasing resource requirements and the perils of organizational transformation.

The US Congress passed the Health Information Technology for Economic and Clinical Health (HITECH) Act, Title XIII of the American Recovery and Reinvestment Act (ARRA) fiscal stimulus package, in 2009 to attempt to align these financial incentives. HITECH provided $25.9 billion in funding for EHR system adoption with the establishment of Medicare and Medicaid EHR incentive programs.[11,12] These programs created payments for clinicians and hospitals who could demonstrate "meaningful use" of an EHR system, and the incentives clearly worked.

The adoption of EHRs has occurred at an astonishing pace, such that by 2015 more than 80% of all acute care hospitals had deployed an EHR system with at least basic functionality, and 96% possessed a certified EHR system in some stage of development.[13]

The three main components of meaningful use (MU), as described in HITECH, are to 1) make actual use of an EHR in a meaningful way, 2) exchange information to improve the quality of health care, and 3) to submit quality measures to the Centers for Medicare and Medicaid Services (CMS).

MU was replaced by the Advancing Care Information (ACI) objectives and measures as part of the Medicare Access and CHIP Reauthorization Act (MACRA) of 2015.[14,15] HITECH and MACRA are designed to incentivize and assist the health care sector to adopt EHRs as a tool for performance improvement.

CRITICAL DECISION

What steps can be taken to protect patient privacy when using EHRs?

Health care organizations are charged with protecting private electronic health information, a key aspect of the Health Insurance Portability and Accountability Act (HIPAA) enacted in 1996. It is imperative for EHRs to provide safety measures that protect this data and for health care organizations to implement policies and workflows to achieve that aim. HIPAA places the onus to safeguard protected health information (PHI) on the covered entity, which can be a medical provider, a health insurance company, or a health care clearinghouse, as well as any business associates the entity uses to assist with its health care activities.[16]

Penalties for violating HIPAA can lead to stiff monetary fines and even criminal prosecution. An intentional disclosure of PHI can lead to a penalty of up to $50,000 and up to 1 year in prison. Using PHI for personal gain or to harm others can result in a prison sentence of 10 years and a $250,000 fine.[17]

Emergency clinicians should alert their immediate supervisor regarding any patient privacy breaches, while following the applicable hospital and federal policies. The Breach Notification Rule requires covered entities and their business associates to report a breach that meets certain criteria. Notifications to those affected by the breach, the Health and Human Services secretary, and the media are required if more than 500 individuals are involved. Penalties vary depending on the severity of the breach and whether it was intentional or accidental.[18]

Although there are limits to what emergency physicians can change regarding federal and state patient privacy laws, they can protect themselves from violations when using the EHR. Additional safeguards can be implemented by working with department, hospital, and IT leadership. Examples include limiting information on electronic display boards in public view, providing privacy screens for outward-facing computer monitors, allowing patients to safely opt out of tracking board screens, and creating policies regarding printed documents.

Many EHR systems still rely on paper printouts for outside providers, for use in another location, or for the patient's own records. The user who printed the information should be identified on the paperwork. Staff should protect all materials printed from the EHR by avoiding transporting PHI outside the workplace and shredding documents no longer needed. As more mobile technology is implemented to complement the traditional desktop EHR, the need to print will hopefully diminish.

CRITICAL DECISION

How can emergency physicians optimize the use of electronic tracking boards?

Tracking boards have transitioned from manual dry erase boards to automated electronic systems incorporated into the EHR. They display vital patient information, while facilitating communication about patient care both within the emergency department and between different departments of the hospital.

An EHR tracking board is essentially a dynamic spreadsheet that can be sorted

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TABLE 1. Tracking Board Elements

Examples of patient information displayed on emergency department tracking boards:
- Patient name
- Room number
- Assigned providers
- Length of stay
- Progress of ancillary testing (ordered, collected, received, resulted)
- Allergies
- Disposition status
- Communication among staff in a free-text column

and filtered (*Table 1*). For example, users can sort rows in order of patient arrival so that those with the longest wait times appear at the top. Even the font and text color can be changed within some systems to denote critical acuity or the status of test results. Patients benefit when providers can readily see this information, and clinicians can also avoid cognitive overload by filtering out patients no longer under their care.

Customizing Features

Many features of the electronic tracking board can be configured with the help of IT analysts and systems designers. For example, icons can be designed and customized to suit individual department needs, and can sometimes be purchased online. Most EHRs employ a tool-tip that explains the meaning of each icon when the user hovers over it. Icons associated with a patient's name can be used to display dynamic information about laboratory and radiology tests.

Dynamic icons change according to the status of a process, while *static* icons represent knowledge or information regarding a specific patient. Examples of static icons include alerts for two or more patients with the same name; an alert indicating isolation requirements; and icons for abnormal vital signs, disposition type, or test eligibility (eg, to comply with a specific regulatory directive). Icons can also protect clinicians when managing potentially violent patients by enhancing communication and alerting front-line staff of inappropriate visitors.

When implemented properly, icons and other elements of an electronic tracking board can be powerful tools to guide clinical workflow.[19] For example, information in a triage note could trigger a sepsis icon on the tracking board, which would then alert staff to initiate a sepsis protocol that would include tasks such as timely blood cultures and antibiotics.

Tracking boards can also provide separate views for different emergency department locations, such as triage, fast/ super track, distinct nursing districts or pods, and critical care areas.[20] Different views of the board can be created for various users, arranging and highlighting data in the most logical manner for specific roles and level of access.

Prior to the advent of electronic tracking boards, clinicians would have to comb through a pile of charts to determine which patients should be evaluated first. Now, when a patient is registered, their name appears on the board, which rapidly notifies the team. Information about prior visits can be obtained and triage vital signs made visible by any appropriate staff member within the department. Furthermore, the tracking board can be viewed, using secure remote access, from an emergency physician's or administrator's home. By evaluating their department in real time, clinicians can make informed administrative decisions about resource utilization and solve issues as they occur.

Perhaps the greatest benefit of this tool is the incredible amount of data it provides. Reports can reveal invaluable information about the timeliness of patient care, dwell times of admitted patients, and compliance with certain core measures such as stroke, pneumonia, and sepsis protocols.[21]

Avoiding Errors

Despite their many benefits, electronic tracking boards can interfere with patient care when certain safety features are not present. For example, imagine how easy it is to order or document an item on the wrong patient when multiple windows are open. It is important for the tracking board to include a prompt that alerts the user when a documentation window is open on one patient but the provider attempts to place an order on a second patient, perhaps thinking they are still working on the previous case. If customization of an EHR allows this multitasking configuration, it is important that multiple cues are built in to prevent the physician from making this mistake.

Clinicians can also suffer alert fatigue from an overly busy, dense, or noisy tracking board.[22] Some systems have too many colors that flash and blink at different rates, where each color has a specific meaning for each staff member. Background colors for cells can be changed to alert the provider about new patients. Theoretically, changes in color or font can be used to denote multiple steps in a workflow, but color-coding can become burdensome if not used selectively.

The overuse of icons can also cause alert fatigue; the provider may overlook an important warning if there are too many to monitor. The best use of color changes and icon management are ones that fit well within the department's workflow and lend themselves to automated processes.

CRITICAL DECISION

What pitfalls should be considered when using EHR alerts?

Alerts can minimize medical errors — as long as a balance is struck between providing timely and relevant information and not impeding the delivery of health care. Alerts appear based on standard or customized computer programming rules running in the background and can draw attention to important information such as patient allergies or the need to address a particular medical issue.

A pop-up alert can serve as a reminder of a drug-drug interaction or the need for infectious disease screening. Icons, color, font, and other user-interface changes are all subtle cues used to draw the user's attention to important information. Alerts can be customized based on certain criteria and can be static or passive. Some alerts require the user to acknowledge them with a click. Others require the user to explain why the alert was bypassed or to select an appropriate response.

The alert user interface must be clean and intuitive so that the clinician clearly understands the purpose of the notice and the possible actions. Alerts in the EHR should also be scaled according to risk-to-patient safety (*Table 2*). Minor notifications should be static and easily bypassed; critical warnings should employ dramatic interface elements and require user input prior to alert dismissal. Using a tiered approach increases compliance among users.[23]

Too many notifications can be dangerous, however. A 2011 investigation by the *Boston Globe* found at least 216 deaths in the US over a 5-year period that were related to alarm fatigue and malfunction.[24] Endless pop-up alerts while trying to enter orders can quickly frustrate busy clinicians, who may then dismiss them as irrelevant. Relevant information may go unrecognized by providers who mindlessly click through steps in the workflow. For example, poorly-timed drug alerts that interrupt with warnings about minor intolerances, potential food interactions, or duplications with historical or home medications are bound to result in patient harm, as the clinician is conditioned to either bypass the alert, or worse, enter false data to complete the desired order.

Alerts that stop an action (eg, order entry) should be designed to help the user discover acceptable clinical actions, in addition to the option to cancel or proceed. For example, if a clinician attempts to order a chest CT with IV contrast to evaluate for pulmonary embolism in a patient with renal impairment, an appropriately designed alert should also give them the option to order an ultrasound of the extremities or a ventilation/perfusion scan instead.

CRITICAL DECISION

How can errors be minimized when entering orders, viewing results, and administering medications?

CPOE plays a key role in coordinating and communicating patient care processes. The electronic ordering of tests allows the emergency department information system to communicate with ancillary information systems in the hospital's laboratory, radiology, and other departments. This approach also decreases transcription errors and reduces length of stay.[25,26] Prior to CPOE, laboratory tests were ordered on paper and results returned by paper or phone; unfortunately, these manual processes are still necessary during EHR downtime.

Creating Order Sets

Great care goes into creating order sets, a process that necessitates a close partnership between the clinical informaticist, the pharmacy and therapeutics committee, and IT project management. Dosages of medications must be thoroughly reviewed for accuracy during the design process. The format of the various sections within an order set should be designed in a logical manner. Interfaces should be laid out to

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TABLE 2. Safety Implications of Major EHR Components

Component	Potential Benefits	Potential Harms
Tracking lists	• Facilitate communication	• Information overload, resulting in communication lapses • Loss of face-to-face communication
Computerized provider order entry and clinical decision support	• Order verification — dose, frequency, allergy, formulary, cost, etc. • Increased adherence to guideline-based care through order sets and pathways • Point-of-care decision instruments and knowledge resources • Surveillance and monitoring of patients, clinicians, and processes	• Alert fatigue • Overreliance on knowledge systems • Increased time spent at computer instead of bedside • Sequencing errors and complex workflows
Bar coding and electronic medication management	• Avoidance of medication errors — wrong patient, wrong drug, etc.	• Overreliance on automation • Missing information
Laboratory information systems and picture archiving and communication systems	• Timely results reporting • Avoidance of accession errors (wrong patient) • Avoidance of repeat tests • Process metrics	• Data retrieval errors — complex interfaces, complex workflows, etc.
Electronic documentation	• Efficient data entry • Legibility • Searchability • Simultaneous access • Availability of prior records • Data reuse and reorganization • Structured data • Data entry validation checks and required documentation	• Overreliance on macros: causing false data entry • Data entry errors, voice misrecognition, autocorrect, transcription, transposition, wrong field, etc. • Voluminous documentation, leading to missed information and cognitive overload • Reduction of patient record to a series of data points, leading to fragmentation of clinical overview of entire patient
Health Information Exchange	• Repeat test avoidance • Medication reconciliation • Continuity of care	• Patient privacy and confidentiality concerns • Missing information • Overreliance on external data instead of evaluating the patient
Patient engagement tools (eg, aftercare instructions, portals)	• Patient education • Patient communication	• Overly broad or generic information • Conflicting information

minimize horizontal and vertical scrolling, which can lead to human and systems errors when the wrong orders are selected. It is helpful to organize the columns of the medication section in the same format as a common prescription. Potential mistakes can also be reduced through integrated safety alerts and reminders. Once designed and implemented, order sets must be periodically reviewed so that the content reflects current standards of care.

Order sets allow separate orders to be grouped together for a common presenting symptom (eg, chest pain) or a clinical event (eg, procedural sedation). They allow the provider to rapidly select what is needed from a single screen, without having to place a series of individual orders. Laboratory studies, medications, nursing orders, and radiology tests can all be included in the order set, which streamlines the management of any given complaint.

In most EHRs, an order set can be customized with fully-defined order sentences or to create a common range of dosages applicable to the situation. For example, in a sepsis order set, a CBC order might have a prepopulated priority of "STAT," and the frequency of an antibiotic might be prepopulated as "once," with the applicable dose range and indication for that condition.

Order sets allow a physician to customize CPOE by preselecting a core set of orders, reducing the number of needed clicks. In addition, they can help facilitate compliance with certain core measures such as stroke, pneumonia, and sepsis bundles. Some system work-flows provide emergency physicians with clinical decision support options at the time of order entry.[27]

Some EHRs allow users to customize the results display to improve visualiza-tion. For example, emergency physicians may prefer to select and view laboratory data in a given time interval in order to analyze any clinically significant trends. Many systems also provide direct access to radiology images without requiring a separate picture archiving and communication system (PACS). However, the image quality is often lower than that of images viewed directly from the PACS software.

Reducing Drug Errors

Clinicians must learn to use CPOE to aid patient safety. Antibiotics, pain medications, and other acute drugs should be ordered as once-only medications. Refills should be ordered via the drug refill process, rather than with a duplicate prescription. The health system must deploy a well-defined medication reconciliation process to keep records up-to-date.

An appropriate, nonintrusive pharmacy review and verification process must be implemented to safeguard against potential interactions and errors. Much literature supports the role of a pharmacist, who can work side by side with the emergency department to reduce costly medication errors.[28]

Another safety-enhancing advancement of the EHR is the use of bar-code verification technology. At the time of registration, the patient receives a bar-coded wristband indicating vital demographic information. Some systems also provide the clinician with a bar-coded ID card with an automated log-in. By scanning the patient's bar-coded wristband, the clinician gains access to the patient's order profile. Scanning the medication next allows that code to be matched with the physician's order. If there is no match, an alert is triggered.

Another advantage to bar-coded medication administration is that the transaction can prompt documentation, potentially saving additional steps in the EHR. These electronic safety checks are a reflection, in part, of the five "rights" of medication administration, where the right drug is delivered to the right patient using the right route at the right dose and right time.

Providers that administer medication have a crucial responsibility to act as the last line of defense against medical errors. Sometimes, the use of technology can lead to a "rubber stamp" effect, where the appearance of correctness is validated by a prior checkpoint. However, some systems provide alerts for incorrect dosing, especially for pediatric medications. It is vital for providers to do a mental check as part of the five "rights" of drug administration and seek help

from pharmacy or online references if questions arise. Computerized systems are not a substitute for clinical review and judgment.

Preventing Alert Fatigue

Although studies show that CPOE can reduce medical errors, technology increases the risk of mistakes related to order entry. One unintended consequence of the EHR is well documented in Robert Wachter's *The Digital Doctor: Hope, Hype, and Harm at the Dawn of Medicine's Computer Age*, which details the case of a pediatric patient who received a 39-fold overdose of sulfamethoxazole/trimethoprim. The physician, who failed to recognize that the computer screen was expecting a dose in mg/kg, instead entered the total dose (160 mg) in the field for mg/kg.

The computer multiplied this input by the patient's weight after the physician bypassed the first computerized alert. The pharmacist, a robot in this case, did exactly as ordered and retrieved a few dozen tablets. Finally, a young nurse, perhaps afraid to question all the checks that had occurred before, administered 38.5 tablets rather than a single tablet. The hospital later pinpointed alert fatigue as the principal cause of the mistake.

Hospital administrators resisted the urge to add another safety alert pop-up, which would have been the first plan of correction at most hospitals. They also removed the mandate to enter pediatric orders in mg/kg doses. In addition, the institution's CPOE now blocks any order that prescribes more than nine pills in a single dose. The robotic pharmacist, which was designed to reduce errors and costs, replaced an independent thinker who could have stopped the cascading set of events that led to the patient's overdose.

Optimizing EHR Design

Other errors (*Figure 1*) that can result from use of the EHR involve poor user-interface design decisions. An order form containing a dropdown list with Celebrex, Celexa, and Cerebyx, along with other medications, is likely to introduce wrong-item selection errors. Documents or order entry screens that require significant horizontal or

vertical scrolling are also prone to user errors. Complex filter options can prevent physicians from seeing all the information needed for patient care. Such individual user settings should be covered during training sessions.

Usability testing and direct end-user input should also be integrated into EHR design, implementation, and maintenance processes. It has been suggested that usability testing follow these five attributes: 1) The system should be easy to learn; 2) an experienced user should be able to use the system efficiently; 3) features should be easy to use and retained once learned; 4) the system should be designed to reduce errors; and 5) the user experience with the system should lead to satisfaction.[29]
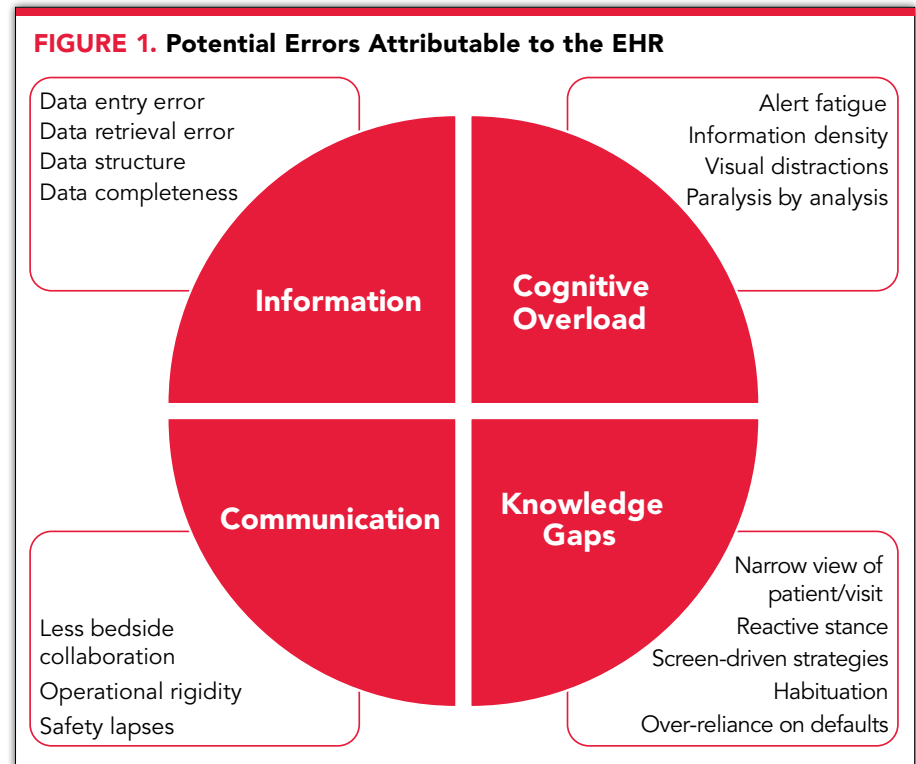
CRITICAL DECISION

How can clinical decision support tools improve patient safety?

Clinical decision support refers to "software that provides clinicians, patients, or individuals with knowledge and person-specific or population health information, intelligently filtered or presented at appropriate times, to foster better health processes, better individual patient care, and better population health."[30] Clinical decision support tools can be categorized by their clinical purpose, mode of alert, method of reasoning, or software architecture.[31]

Many tools currently exist that can aid in diagnostic reasoning by leading the provider through the application of formal guidelines and decision instruments (eg, PECARN algorithm, GCS score, etc.). Some can gather relevant information from the patient's chart and, if documented in a manner that supports retrieval and processing, be used to prepopulate decision aids. More advanced systems can feed a rule engine to evaluate for specific conditions of interest — such as sepsis, potential syndromic or public health alerts, risk of clinical deterioration, delirium risk, or risk of falls — and alert staff.

Other tools can provide treatment recommendations based on best

FIGURE 1. Potential Errors Attributable to the EHR

Information
Data entry error
Data retrieval error
Data structure
Data completeness

Cognitive Overload
Alert fatigue
Information density
Visual distractions
Paralysis by analysis

Communication
Less bedside collaboration
Operational rigidity
Safety lapses

Knowledge Gaps
Narrow view of patient/visit
Reactive stance
Screen-driven strategies
Habituation
Over-reliance on defaults

practice guidelines or provide specialty or disease-specific chart views to help providers quickly summarize key information and view trends. Properly designed clinical decision support systems, deployed with attention to provider workflows, are one of the key drivers of quality improvement; however, many of these tools remain inadequate.

An ideal decision support system should "provide the right information, to the right person, in the right format, through the right channel, at the right point in the workflow to improve health and health care decisions and outcomes."[32] However, clinicians most often interact with a decision support system via inopportune pop-up alerts, when opening the patient's chart or during the order entry process. Otherwise, the tool is a separate module within the EHR (or even in a different application or web browser window) that must be launched, requiring clinicians to reorient to a different interface, work through the tool until arriving at a decision, and then execute the decision back within the main EHR workflow. Major EHR vendors have made significant progress in allowing the integration of third-party tools into their clinical workflows, but implementations vary widely.

In addition to these discrete support modules, decision support also includes the design of the EHR interface, which dictates how information is presented to clinicians. Rather than launching individual tools for specific clinical problems, system designers should optimize how test results and other pertinent clinical data are integrated into the clinical decision process. For example, when ordering a test, the date and value of the last performance should be displayed in context. Information on best practices for diagnostic tests or treatment options should be immediately available to clinicians and integrated into the ordering workflow.

Standardizing Care

An emerging model for contextual decision support is the "infobutton," a Health Level-7 standard for embedding outside resources in appropriate areas of the EHR.[33] An infobutton can appear as an icon or a hyperlink to a resource with additional information. Drug monographs, links to guidelines, calculators and scoring instruments, equipment manuals, and just-in-time training materials can all be linked to individual orders and order sets, documentation systems, laboratory test

descriptions, and other areas of the chart subject to the EHR system architecture.

Access to material at the point of decision helps to standardize care based on best practices and institutional protocols by improving access to clinical resources. This information, which is critical to making optimal diagnostic and treatment decisions, should not be squirreled away in some email archive, intranet site, handbook, or other external resource.

Despite the clear usefulness of contextual references, high-risk cases demand more formalized decision support tools. Thrombolytics, anticoagulation, blood product administration, surgical intervention, and many other situations require the use of checklists and order sets to provide safe and effective care. Specific documentation forms and checklists to formalize inclusion and exclusion criteria for high-risk therapies should be available to the provider, and their use should be enforced via institutional policy, rules engines, modal alerts, and system design.

Order sets for high-risk and protocol-based care situations should be up-to-date, clear, concise, and user-friendly with reasonable default parameters. Institutional order sets should be localized by care setting, rather than implemented indiscriminately throughout all departments. Dosing calculators should automatically appear for medications, such as chemotherapeutics, thrombolytics, weight-based drips, and insulin with relevant information, such as age, body weight, height, and calculated body surface area immediately available. Automatically calculated values (eg, a final weight-based dose) must be highlighted to attract the attention of the ordering provider. Basic measures, such as standardized limited formularies with drug concentrations and units of measurement (mL, mg, cm, etc.), are also critical to preventing patient harm.

Rules engines can further improve patient flow by suggesting additional orders or automatically placing orders according to protocol. For example, elevated lactate in a patient with suspected sepsis can be automatically repeated by rule, without requiring the clinician to view the abnormal result and order a repeat. Orders can be automatically entered for certain diagnoses when their performance is routine for that condition. Clinicians can be prompted with additional orders that commonly go together or are required for patient processing, including MRSA testing for bed placement or isolation orders.

Developing Order Sets

Order sets should be developed and maintained with best practices in mind and viewed as an essential form of decision support. This makes it easy for the clinician to "do the right thing" by including only necessary and safe orders that align practice with accepted norms. Order sets should also cover a limited number of standardized patient pathways for disorders such as asthma, chest pain, trauma, or sepsis, and should reflect the clinical staff's practice.

Order sets should not be confused with quick-pick or favorite lists of possible orders for a given complaint, which can add clutter and slow down the ordering process by requiring clinicians to scan a seemingly endless list of options. Too many choices can cause cognitive overload and lead to errors. Instead, common orders for general workups and specific conditions should be grouped as quick-pick or favorite lists that exist outside of order sets and should be organized redundantly via test modality, clinical complaint or diagnosis, or the step of the patient visit (eg, triage, evaluation, or disposition).

It is critical to remember that clinical decision support systems do not make clinical decisions; they merely provide relevant information and analyses to enable clinicians, patients, and health care organizations to develop more informed judgements. Providers should not blindly trust the recommendations of any clinical decision support tool or the configured defaults of any order.

CRITICAL DECISION

What steps are required for proper development and continued maintenance of EHRs?

Although the transition from paper medical records to an electronic format is challenging, it is an investment in the future. The more time and effort spent creating and modifying electronic notes, the easier it is to document the patient's next visit.

During EHR implementation, the emergency department director or designated IT clinical champion should work closely with a clinical documentation analyst to convert existing notes, forms, and templates. New documentation should be designed only after considering changes in operational and clinical workflows as a result of the EHR. It is a common pitfall to replicate paperwork with electronic forms or templates without regard to the purpose that the paper documents served. Another common mistake is attempting to duplicate the layout and structure of existing paper forms. It is important to remember that screen-based interfaces necessitate a very different approach.

Paper documentation can help providers organize and process care for needle sticks, central lines, and deaths within the emergency department, but they can also communicate information to other departments, including data on employee health, quality management, or vital statistics. For example, if a paper death packet is formatted electronically, but the EHR implementation team fails to recognize that it also serves to inform the office of vital statistics of a patient's death, then its full purpose will not be achieved.

One solution may be to send automated emails to the office of vital statistics if certain questions, already present in the electronic form, are answered in certain ways. Some forms of electronic documentation can trigger events based on data entry, such as adding diagnoses, prompting for additional information, or automatically placing orders. Alternatively, some actions and events can be automatically converted into embedded documentation within clinical notes (*Table 3*).

Design sessions should also be influenced by the regulatory requirements the hospital must follow. Examples include a text box reminder for do-not-use abbreviations, or documentation on the use of two

patient identifiers or an interpreter.[34] A multidisciplinary group can determine which fields should be mandatory to drive compliance for billing or for quality needs in cases of stroke, sepsis, acute myocardial infarction, or heart failure. Ensuring regulatory compliance, which is a concern for all hospitals, is a distinct advantage of electronic documentation. Although these needs can conflict with the desire for short, user-friendly electronic notes, they are a vital part of the process.

After EHR implementation, it is important to maintain and update documents on a regular basis. Paper versions of electronic documents may be needed when the system is offline; therefore, changes in one version should be matched and completed in the other. Users should also be aware of any changes in existing clinical documentation.

Helpful Shortcuts

Despite daily frustrations with clinical EHR documentation, many tools are provided to ease these tasks. Many systems have a "canned expressions" function that allows physicians to document templated text using a key word; however, this tool is best used for tasks that require the same documentation all the time. For example, physicians can provide discharge instructions for patients needing wound care or those with high-risk conditions that do not merit admission.

Processes that occur earlier in the patient workflow can also be utilized to ease documentation. For example, information entered by a provider at triage in one document can populate certain sections of the emergency physician's note and provide an opportunity for correction. Optimally, data should be entered once and then be available in the chart going forward. A patient's allergy history is a great example of key data that should be entered in the designated section of the EHR. It is imperative that every provider have access to this information.

An important distinction should be made, however, between functionality that allows "canned expressions" or "bring it forward" documentation and cutting and pasting from one note to another. Per CMS, cutting and pasting of clinical documentation makes it easier for clinicians to commit fraud.[35] Having a more user-friendly way to document patient information serves to enhance patient safety and compliance, as long as the correct methods are used.

Avoiding Common Mistakes

Users tend to develop shortcuts and workarounds in an attempt to enhance efficiency and avoid unoptimized areas of the EHR. For example, it is common for providers to document a patient's allergy history as free text, rather than as structured data in the allergy module. This workaround is a patient safety hazard, as any free-texted allergy history will fail to trigger drug-allergy or drug-drug interaction alarms, and will not be included in transition-of-care documents or summary information. Such bounded, discrete data elements should be entered once and used again anywhere and anytime they are needed.

User-friendly features that document a whole review of systems (ROS) with one or two clicks are also commonly misused. Obvious examples of misuse include a comprehensive ROS documented for a gunshot victim at a level one trauma center, "alert and oriented" for the neurological examination of a cardiac arrest patient, or "moves all extremities" for a paraplegic patient. Scribes can be helpful in these circumstances, provided the charts are reviewed carefully. Although they can provide valuable documentation services, it is important to remember that

TABLE 3. Suggested Documentation Filters

Filter	Included Documents	Excluded Documents
Emergency (default)	Clinically-relevant visit information, including triage notes, patient history, examination findings, nursing notes, care summaries, and discharge instructions	Registration, billing, and other administrative information
Cardiology	ECGs, echo and catheterization reports, emergency physician procedures, cardiology consults, and cardiology office notes	Procedure logs, circulating nurse reports, and anesthesia reports
Procedures	Operation dictations, endoscopy reports, interventional radiology procedures, and implant logs	Procedure logs, circulating nurse reports, anesthesia reports, time out notes, and administrative notes
Studies	Radiology reports	Administrative, billing, and regulatory notes
Inpatient summary	Admission, history and physical exam, daily progress notes, consult reports, discharge summaries, and transition-of-care documents	Any other inpatient documentation
Inpatient	Admission, history and physical exam, daily progress notes, consult reports, discharge summaries, transition-of-care documents, nursing documentation, physical therapy notes, and other ancillary reports	Administrative, billing, and regulatory notes
Primary care	Primary care provider notes, patient-recorded information, patient call logs, and referral reports	Administrative, billing, and regulatory notes
Outpatient	Specialist provider notes, patient-recorded information, and patient call logs	Administrative, billing, and regulatory notes
Advanced directives	Physician orders for life-sustaining treatment (POLST) forms, living wills, and power of attorney documentation	
All	Unfiltered documentation	

scribes are a workaround.[36] By intercepting patient safety alerts and decision support information, scribes filter information intended for the ordering provider. As such, they should be mandated to consult their supervising physician when faced with these alerts.

CRITICAL DECISION

How can clinicians leverage the Health Information Exchange to provide safer patient care?

The process of calling the medical records department of another institution to locate a patient record, requesting written patient permission to retrieve the record, faxing that request and permission to the other institution, and then awaiting a return fax for the relevant records is all too familiar to most emergency physicians. Now, instead of a concise discharge summary or study report, physicians receive EHR printouts that include a wealth of often marginally relevant data and are left to hunt for the one critical fact requested.

Instead, a clinician should be able to query the EHR of another institution or patient registry to directly obtain information about a patient in real time. Traditionally, each EHR was an island unto itself, largely inaccessible to other computer systems and external providers. Effective data interchange relies on widely adopted data messaging standards and protocols, as well as shared data definition templates. Development and refinement of these many taxonomies, terminologies, hierarchies, and messaging standards have progressed over the past several decades within seemingly innumerable standards development organizations.

HIPAA and HITECH mandated the use of specific standards and provided incentives for specific foundational and structural interchange capabilities, spurring meaningful progress toward interoperability among the major EHR vendors.[37,38] Despite decades of work and for multiple technical, logistic, political, and economic reasons, few clinicians can directly exchange information between EHRs deployed at different institutions. The popularization of Fast Health Interoperability Resources (FHIRs), lightweight standards for developing and deploying modules for interoperability, promises to dismantle technological barriers.[39] A more practical solution, however, is to use a combination of the Direct Project and HIE networks to facilitate the exchange of patient care information between providers and institutions.

Sharing Information

Research shows that many opportunities for errors occur during transitions of care. In the US, the typical Medicare patient sees seven different physicians across four different practices per year, and many with chronic conditions see more than 16 physicians per year.[40] To this end, the Direct Project, which is essentially secure email for clinical documents, has been developed and is now part of MU requirements.[41] Each clinician and institution has a direct address, from which they can send and receive clinical documents regarding a patient. The current focus is to implement transmission of important clinical data encapsulated in the Continuity of Care Document (CCD) standard between EHR systems.[42]

These documents are human-readable and can thus be forwarded to the patient's chart in the receiving EHR. They are also structured documents, so they can be parsed by the EHR to populate the receiving system with meaningful discrete data elements such as allergies, medications, and potential complications. The included data elements can be customized to meet particular needs or populations, yet remain standardized and reusable.

A direct point-to-point secure email exchange of clinical information is feasible with defined relationships (eg, a sending-and-receiving facility or a referral for follow-up care). However, a third party is necessary for many interactions. HIEs or Regional Health Exchange Organizations (RHEOs) exist to facilitate information exchange between multiple providers and institutions within a region. Typically, hospitals, health plans, outpatient laboratory and imaging centers, and even individual provider offices within a region come together under a legal and financial arrangement to exchange a predefined set of clinical data in a standardized format.

This interchange can be set up in a federated model, where each institution "owns" their data and provides information based on specific queries, or data can be copied directly into the HIE repository. Some systems are integrated into the local EHR, whereby the results are formatted by the HIE into a structured document for import into the EHR into a designated area of the patient's chart, sent as a direct message to the individual provider's inbox, or delivered to a common institutional inbox. Others operate as a separate, often web-based, application.

Pearls

- Aftercare instructions should be written at a sixth-grade level to improve patient comprehension.
- Essential patient information, including medications, allergies, and pregnancy history, should be documented in the designated EHR areas. This structured data ensures that other providers are made aware of critical information during current and future visits.
- Emergency physicians should make modifications to electronic tracking boards to enhance readability and situational awareness.
- It is important to work with local institutions, including rehabilitation and long-term care facilities, to develop structured electronic documentation exchange via CCDs and direct messaging.
- Patient privacy breaches should be escalated and immediately reported to the direct supervisor.

Some HIEs query the patient's insurer to obtain claims summaries, which can include information on prior encounters, diagnoses, prescription records, and procedure codes. While useful, the data is often limited to the current insurer and may not be applicable to noninsured patients or those with policy changes. Furthermore, the information is claims based and does not provide a full and accurate picture of all patient encounters.

Barriers to Care

A clinical data repository of structured data is much more robust than payer query systems, yet few currently contain unstructured documentation (eg, provider notes or diagnostic images). Some HIEs store a shadow copy of a subset of the patient's information; others support an indirect query of the target institution's EHR to obtain information as requested. No clear standards on how to design these systems exist, as every EHR and institution employs different charting and coding practices.

Moreover, regional exchange operators face varying state and local regulations regarding the receipt, storage, and dissemination of patient information. Other barriers to HIE sustainability include the competitive nature of local health care institutions and the potential unwillingness to share clinical data, the data architecture decisions and technical limitations of the member institutions, and the issues surrounding board structure and funding for the development and ongoing maintenance of the exchange.

It is important to remember that all information exchange relies on robust patient identifier matching standards, master patient indices, and record locator services.[43] Patients frequently provide differing information during registration, including variations of first and last names, maiden names, various addresses, or old phone numbers. Social security numbers, which are an unreliable single identifier, have been reused and reissued, are a target for identity theft, and are often incorrectly remembered or reported.[44]

Thus, the US does not have any form of reliable national unique identifier, and despite HIPAA language mandating it, the US Department of Health and Human Services (HHS) is prohibited via statute from establishing one in each appropriation.[45] Physicians should ensure that the correct patient records are returned by the HIE; should validate demographic and clinical information they receive; should view clinical documents as a snapshot in time, consisting of what was known about a patient or reported during that episode of care; and should be skeptical of the source and veracity of data abstracted from individual encounters.

The exchange of health information between providers can substantially aid patient safety efforts by decreasing radiation through the elimination of unnecessary studies, improving the accuracy of reported treatment histories, and enhancing the coordination of care. Efficient exchange of information can also decrease costs by increasing the reliability of completed studies, especially if fully detailed reports, descriptions, and even images accompany the final interpretations.[46]

Prescription Drug Programs

All US states except Missouri, as well as Guam, Puerto Rico, and the District of Columbia, have an active prescription drug monitoring program (PDMP).[47] The timeliness of reporting to the PDMP varies, however, and can impact the relevance of the report.[48] Some states mandate query of the PDMP upon prescribing and documentation of such activities.[49] These programs are primarily designed to prevent drug diversion and abuse of scheduled medications and to simplify drug enforcement actions. Nonetheless, patients who are abusing scheduled drugs pose a hazard to themselves, and possibly to the public, and are a source of great frustration to many providers.

Most pharmacy benefits management (PBM) programs are now part of a nationwide prescription information exchange network that aggregates patient prescription records. Modern EHRs can query this database, allowing providers to see prescription fill data, which can greatly aid patient care. Patients often have incomplete or missing medication lists, and few have knowledge of drug names and accurate dosages. Many of these systems can be integrated into an EHR's medication reconciliation workflow.

Providers should remember, however, that the absence of PBM records does not ensure that the patient is not taking a medication. Not all pharmacies directly report to PBM exchanges; therefore, information can be missing or delayed. The sole information source in these cases is claims data. Furthermore, if patients do not have or do not use drug insurance coverage for a medication, it may not appear in PBM records. Physicians should use the prescription query to check patient reports or obtain additional details, but should verify all information with the patient, family, or prescribing provider.

Patient Portals

Patients will increasingly have access to electronic tools to help them manage their own health care data. This wealth of information can assist in diagnosis, guide therapy, coordinate care among multiple providers and settings, and track progress toward health and care goals.

Most modern personal health records (PHRs) are portals tied to provider EHRs, which allow patients to view a subset of their provider-generated notes, laboratory results, imaging records, educational materials, aftercare instructions, and administrative data. Due to MU incentives, patients are increasingly able to access a wide array of personal clinical data and specific educational material assigned to them based on their health issues. Often, patients and their proxies can view test results even before the clinician has had a chance to review them, so some systems delay publishing to the patient portal to allow time for provider review.

Some systems also allow patients to manage appointments via the portal, issue reminders, support direct communication with providers, allow patients to edit or annotate their own records, or upload documents. Still others provide health applications to monitor and trend physiological and laboratory data or to monitor care plans and specific milestones or targets. PHRs are developing rapidly within the context of EHRs, with shifting approaches and technologies. The aim is to develop useful tools and data patients need to achieve their personal health goals.

CRITICAL DECISION

What is the most effective way to provide aftercare instructions?

Prewritten discharge information and educational material can be an excellent driver of increased patient safety and satisfaction; however, most of these documents are less than ideal. Many health care systems purchase a patient education package from a vendor; these materials are often overly generic, incomplete, and in direct conflict with oral instructions provided at the point of care.

A better plan is to create simple handouts, aimed at a sixth-grade reading level, which are standardized across the department and not necessarily the same as the set used for hospital discharge or outpatient offices.[50] For example, take the top 20 discharge diagnoses and create standardized paperwork that includes aftercare instructions, follow-up information, referrals to local community resources, and reasons to return.

Most commercial EHRs allow providers to add specific additional treatments or other information, using personal macros or custom instructions. If this is not possible, the information can be saved as dated word processor files in a shared location. These patient education materials must be regularly reviewed and updated. As with all content, identify subject matter experts and assign one person as the content owner, someone who is responsible for reviewing the materials at appropriate intervals and serves as a contact for comments and questions. Choose a high-quality vendor, whose content is also regularly audited by subject matter experts, for the remainder of the library. Disable or remove content that does not reflect current knowledge or practice patterns.

Patients should also receive a set of patient-specific instructions, containing aftercare instructions, medication prescriptions, and follow-up information. This document framework is typically configured as part of system implementation and can usually be improved upon. For example, some systems print full medication reconciliation sheets at discharge. This is a valid approach for closed systems in which the patient receives all care within one facility or network and all providers are utilizing a common EHR framework. However, if the system is not closed, this approach can introduce errors of omission. A simple list of new medications prescribed during the visit, and notes about any that should be stopped, should suffice.

Medication changes should still be added to the patient's electronic medication list as part of MU-mandated discharge medication reconciliation. However, physicians should not assume that these changes will properly print on discharge instructions in a manner that patients can understand and act upon, unless they have been carefully configured to do so.

Discharge instructions commonly list follow-up appointments. Clinicians should ensure it is clear whether these appointments have already been made for the patient or the patient needs to schedule them. Someone in the organization, preferably a member of the medical staff office, should regularly review and update the provider database with names, addresses, and contact information so that patients can successfully schedule their appointments. If possible, staff should schedule appointments for patients and use an automated reminder system (phone call or text message) to improve adherence.

Some discharge sheets list tests and procedures performed, and some include results. Emergency physicians should ensure preliminary results, such as radiology wet reads, are properly labeled. Much of this information is also available in the patient portal, so detailed results may not be necessary, especially if they are not interpreted or finalized at the time of discharge.

Summary

The deployment of an EHR does not, in itself, improve health care. It is merely a tool that enables the organization to leverage its resources to improve organizational efficiency and the provision of patient care. As such, the deployment and maintenance of health IT is an opportunity for continuous quality improvement. The installation of a comprehensive EHR system in a complex clinical environment is an inherently disruptive process, requiring significant organizational change and work adaptation. Attempting to replicate the prior paper-based system through extensive customizations and unique rules cannot produce new operational efficiencies, and will only frustrate attempts to improve safety via novel errors and workarounds.

CASE RESOLUTIONS

■ CASE ONE

The physician informed his medical director of the misplaced paper notes. Both were relieved to find that only a small number of patients were affected, so the scope of this incident did not require them to notify the federal government. The hospital's security officer informed both patients, however, and the hospital decided to re-educate its employees on existing policy regarding patient privacy: Employees are not allowed to transport patient health information outside the hospital unless it is encrypted.

Violations of the HIPAA and the Breach Notification Rule require covered entities, such as emergency physicians, to notify certain individuals when a breach meets certain criteria. For a case that involves a breach of more than 500 individuals, notifications to those affected by the breach, to the HHS secretary, and to the media are required. If the breach is found to be intentional, severe financial and criminal action penalties can be imposed.

■ CASE TWO

Although the proper alert was triggered for cross-reactivity between the patient's allergy to penicillin and treatment with a cephalosporin, the physician bypassed it due to alert fatigue. The patient developed an allergic reaction to IV ceftriaxone and was treated appropriately with a good clinical outcome. However, the patient filed a complaint with the hospital. The hospital then changed the EHR system to require the user to give an explanation for bypassing an allergy alert. The nurse who administered the medication should also have asked herself if the dose, frequency, and type of medication made sense for the patient, since the knowledge-based bar coding system simply affirms the mistake.

Assuming that the medication is appropriate because the bar-coded patient wristband matches the bar-coded medication creates a confirmation bias. Mistakes can be made even after applying the five rights — the right patient, right drug, right dose, right route, and right time — of medication administration, so retaining critical thinking while administering medication is vital. The hospital could also add another layer of medication safety by requiring an emergency department pharmacist to verify all medication orders.

■ CASE THREE

The physician looks at the order and notes it matches the patient's weight. She enters another order for hydromorphone, entering "1" in the dose quantity field and then choosing "mg/kg" instead of the default "mg" in the dose unit field, and sees how the dose was changed to 68.7 mg. Due to a recent system update, the EHR now automatically calculates weight-based doses within the order entry field if a weight is entered, as required by triage protocol, rather than requiring the use of a pop-up dose calculator to calculate and round doses, as was done previously.

These automatic order alterations were not highlighted by the system, which led to the near-miss in incorrect dosing, as the physician likely hit a key that changed the default from mg to mg/kg between clicking on the order sentence and clicking the sign button. Since the physician was not expecting the entered dose to change, as the order was a precomposed favorite, she did not thoroughly review the final order on the signature page. It is important for clinicians to be informed of system changes and review all orders prior to signing.

Well-designed EHR components can gather and summarize data, simplify processes, and speed communication. The end goal should be to leverage the available information and computing power through EHR-powered workflows. As there is a limit to how much change people can absorb at once, incremental implementation and updates, coupled with ongoing and repetitive training, can help minimize temporary productivity losses.[51]

Groups of clinicians should bear the responsibility for developing care protocols, order sets, lists of common "favorite" or "quick-pick" orders, and information resources at the department level to optimize patient safety, speed clinical workflows, and standardize care. These CPOE elements can be leveraged to provide decision support and make it easier to "do the right thing" through standardized complete order sentences with reasonable defaults common to the clinical setting, through concise groupings of common companion orders based on best practices and evidence-based guidelines, and by eliminating orders of limited clinical usefulness to discourage use.

Once developed, care processes, order sets, and documentation aids must be maintained to ensure they function optimally in the face of continual change. Every individual workflow must have an owner who is invested in and empowered to monitor the process and make adjustments as necessary.

Subject matter experts should be directly responsible for performing regular content reviews of rules, guidelines, and order sets based on current evidence and organizational capabilities.

Ideally, this work should proceed across departmental lines, as it is far easier for managers and IT personnel to adapt standardized plans and protocols across an institution than to create and maintain separate procedures for every individual department. This standardization leads to safer care through familiar work processes, uniform formularies, consistent interfaces and data elements, and simpler EHR maintenance.

The overarching goal is to develop a "learning health care system" that uses

clinical data and best practices to help provide the safest, most effective care possible to individual patients while simultaneously improving population health and delivery models through data analytics.[52] Much work is yet to be done by the government, vendors, payers, health care organizations, providers, and even patients. However, modern EHRs are essential to enabling future improvements in health care delivery and clinical research.

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