Commentary

Information technology to improve patient safety: A round table discussion from the 5th International Patient Safety Forum, Riyadh, Saudi Arabia, April 14–16, 2015

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Submission: 26-07-2015
Accepted: 26-10-2015

Access this article online

Quick Response Code:

Website:
www.thoracicmedicine.org

DOI:
10.4103/1817-1737.176877

A simple definition of patient safety is the prevention of error or harm associated with healthcare. An up-to-date definition is more holistic. Patient safety has expanded to include providing high-quality care.[1] The goals of patient safety have similarly expanded to include delivering evidence-based care in a timely manner rather than just eliminating errors.

Information technology (IT) has wide-ranging spectrum applications in patient safety in the acute care setting and, in particular, the Intensive Care Unit (ICU) setting. Throughout this paper, we provide a summary of the discussion from the roundtable meeting from the 5th International Patient Safety Forum, held in Riyadh, Saudi Arabia on April 14–16, 2015 that covered several aspects of how IT can improve patient safety, with a focus on the ICU setting. The format of the roundtable included presentations and general discussions. The potential risks associated with novel IT methods and technologies were also discussed. The meeting provided evidence by showcasing specific successful IT projects.

Healthcare, particularly ICU care, is complex and involves multiple processes. Defect rates are estimated to be in the order of 1/10 to 1/1000, making healthcare frequently unreliable.[1] Arguably the most important goal of modern healthcare is standardization and improvement in reliability. Standardization means the provision of the same good medical care to all patients. It involves the implementation of evidence-based clinical practice guidelines. IT can help standardize a complex healthcare. Table 1 describes steps for standardization of care using health IT.

Computerized physician order entry (CPOE) systems are already transforming healthcare. These systems are widely used and are recommended by the Institute of Medicine[2] to improve patient safety and reduce errors. CPOE is the use of an institutional computerized health record to electronically enter orders. The technology often includes prompts, alerts, dose calculators and interfacing with laboratory and radiology test results. The value of CPOE lies in optimizing order communication, providing real-time decision support, and facilitating standardization of care [Table 2].

The completion of a single medication dose requires executing many steps.[3] Errors can happen at any of these steps. An ICU study found that the most common error types were wrong dose (11.7%), wrong administration time (13.9%), dose omission (14.4%), and wrong administration rate (40.1%) with the commonly involved medications being antibiotics, electrolytes, cardiovascular drugs and sedatives/analgesics.[4] A prospective study compared a paper-based ICU and a CPOE-ICU. The study found that the CPOE-ICU had a lower incidence of medication prescription errors (3.4% vs. 27.0%) and adverse drug events (2 vs. 12).[5] A recent systematic review estimated that processing a prescription drug order through a CPOE system decreases the

How to cite this article: Arabi YM, Pickering BW, Al-Dorzi HM, Alsaawi A, Al-Qahtani SM, Hay AW. Information technology to improve patient safety: A round table discussion from the 5th International Patient Safety Forum, Riyadh, Saudi Arabia, April 14–16, 2015. Ann Thorac Med 2016;11:219-23.

Table 1: Steps to perform standardize care using health information technology

Identify a high-priority clinical process
Identify a champion for implementation of change
Obtain senior leader support
Build an evidence-based or best practice protocol
Involve all stakeholders in developing process change and the protocol for successful buy-in
Blend the protocol into clinical workflow (clinical decision support; default choice that happens automatically unless someone must modify)
Allow clinicians to vary based on patient needs. This will also help buy-in and increase compliance
Embed data systems to track
Protocol variations
Short- and long-term patient outcomes
Establish a mechanism to provide feedback regarding the results of protocol variations and patient outcomes to front-line staff
Keep the focus small to begin with, then expand

Table 2: Benefits of CPOE

Domain	Benefit
Optimization of order communication	Eliminates illegible handwriting
	Avoids transcription errors
	Improves accuracy and completeness
	Provides real-time access to patient records
	Speeds up response time
	Improves physician identification
Real-time decision support	Suggests drug doses, routes, and frequencies
	Provides information about drug-drug and drug-lab interactions
	Provides alerts on allergy to drugs
	Provides information about potential drug complications
	Provides alerts on disease specific situation (digoxin and K^+; antibiotic dose and kidney function)
	Facilitates recognition of certain conditions (such as recognition of severe sepsis based on electronically documented vital signs and abnormal laboratory results)
	Suggests provision of evidence-based therapies
Standardization of care	Defaults optimal drug dose
	Facilitates provision of agreed-on orders/order sets/protocols
	Suggests evidence-based interventions
Audit	Facilitates audit of healthcare processes in real time

CPOE = Computerized physician order entry

likelihood of error on that order by nearly 50%. It was projected that >100,000,000 medication errors could be averted if CPOE was adopted in all US hospitals.[6]

Incorporating decision support systems into CPOE has also been shown to be beneficial. A before-after CPOE-ICU study, with an integrated clinical decision support system, showed a decrease in the erroneous prescription of medications to which patients had reported allergy from 146 to 35 ($P < 0.01$), a decrease in antibiotic-susceptibility mismatches from 206 to 12 ($P < 0.01$), reductions in the number of days of excessive drug dosage (2.7 vs. 5.9 days, $P < 0.001$) and a decrease in adverse drug events from 28 to 4 ($P < 0.01$). Another before-after study found that an evidence-based computerized decision algorithm for red blood cell transfusion in an adult ICU was associated with a decrease in the number of transfusions per ICU admission from 1.08 units before to 0.86 units after the protocol ($P < 0.001$), in the rate of inappropriate transfusions (17.7% vs. 4.5%, $P < 0.001$) and in the rate of transfusion complications (6.1% vs. 2.7%, $P = 0.015$).[7] There are many other examples of CPOE facilitating protocol implementation and thus improving patient outcomes. Examples include the management of hyperglycemia,[8] acute myocardial infarction[9] and chemotherapy regimens.[10] A before-after study conducted in the ICU at King Abdulaziz Medical City, Riyadh (KAMC-R), Saudi Arabia found that CPOE implementation was associated with no change in ICU and hospital mortality in the immediate period and up to 12 months after implementation.[11]

However, the introduction of CPOE systems can introduce substantial vulnerabilities. Any change in medical care can be accompanied with unintended consequences.[12] A study at a tertiary-care hospital found that a new CPOE system facilitated 22 types of medication error risks, as a result of fragmented CPOE displays, false interpretation of dosing guidelines, inflexible ordering formats, delayed ordering due to system unavailability and other factors.[13] CPOE may also change workflow such that CPOE becomes time consuming leading to less time spent with the patients. Moreover, it may increase the clinician's reliance on IT instead of face-to-face verbal communication with other healthcare providers for planning and coordinating their work. Hence, CPOE system implementation should be well planned and should involve all stakeholders. Potential vulnerabilities should be considered and addressed before the Go-Live. The system performance should be audited and continuously enhanced according to the specific hospital's needs. The effect of CPOE on various stakeholders, such as physicians and nurses, its impact on patient safety and other patient outcomes and its cost-effectiveness should be studied in randomized controlled trials.

A basic CPOE system allows physicians to improve care by reducing errors and standardizing treatment from the time of initial diagnosis or recognition of a clinical problem. However, compliance with the best practices also requires clinicians to reliably identify patients requiring specific treatment early and respond quickly to new clinical problems. Modern technology means that more of the information required to deliver timely care is available, but this information needs to be delivered to physicians to help them act quickly and reliably. Electronic alert systems can be adapted to aid in the diagnostic process. For example, in a large randomized controlled trial, with over 2500 patients, patients were randomized to either an intervention group, with the physician receiving a computer alert of the patient's venous thromboembolism risk or to a control group with no alert. There was a clinically and statistically significant improvement in care in the intervention group: Mechanical prophylaxis (10.0% vs. 1.5%) and pharmacologic prophylaxis (23.6% vs. 13.0%).[14] Two successful IT projects from KAMC-R, where alert systems have been used to improve clinical care, were presented at the 5th International Patient Safety Forum. These were the automation of the communication of critical laboratory results and severe sepsis and septic shock alert system. The details of these two IT projects are summarized below.

The technological advances in laboratory medicine, including automation, have dramatically improved the accuracy and speed of patient testing. However, the communication of critical laboratory values (CLVs) to clinical staff has not kept pace with these technological changes.[15-17]

Until recently, laboratory staff at KAMC-R were required to contact physicians and inform them of CLVs manually using a telephone or pager. This process was time-consuming for lab staff and resulted in significant delays in the transfer of critical information. The identity of the requesting physician was often unclear as was the escalation process, with differing departmental policies, and often there was reluctance from the contacted physicians to accept responsibility for managing the associated clinical problem. Using this manual reporting process, it was not possible for KAMC-R laboratories to meet their performance target of communicating CLVs reliably within 15 min (from confirmation of the results until acknowledgment from the clinician of the results). An IT system was designed to automate the communication of CLVs to the relevant physician.

The impact of automation has been significant [Figure 1] with results being reliably communicated to the appropriate department within the target time frame and laboratory personnel now have more free time to handle their other responsibilities. The healthcare providers are now more likely to accept responsibility for the CLVs knowing that a computerized system has identified them as the appropriate providers. Finally, an automated system means that monitoring the performance of CLV communication is easier, with the real-time availability of data and automated reports.[18]

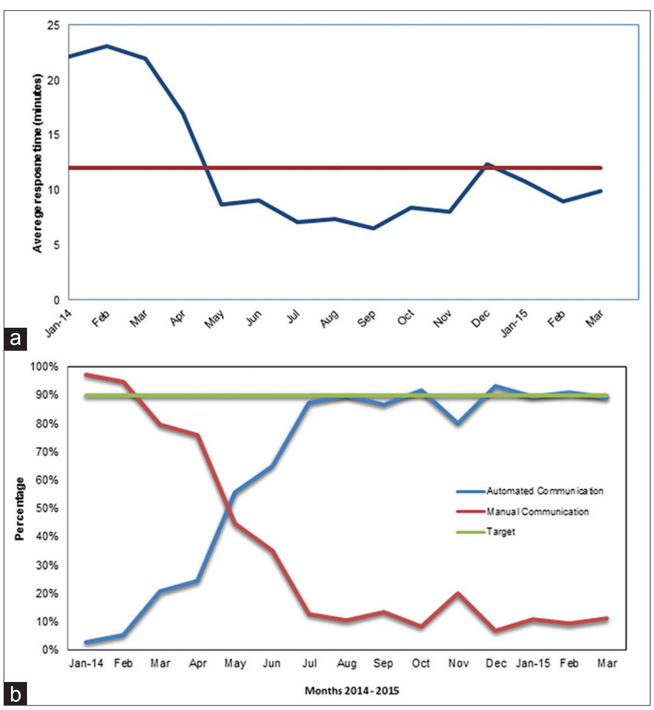

Figure 1: The impact on the time to notification (a) and the percentage of critical results notified within the target time frame (b) as a result of switching from a manual to an electronic notification system (b) at King Abdulaziz Medical City, Riyadh, Saudi Arabia

Several studies have demonstrated poor compliance with evidence-based guidelines for the management of severe sepsis and septic shock. One key factor causing poor compliance is delayed recognition.[19] The 2012 Surviving Sepsis Campaign guidelines recommended routine screening for severe sepsis to allow earlier initiation of therapy.

Several screening tools using different combinations of severe sepsis and septic shock criteria have been studied.[20,21] At KAMC-R, an electronic sepsis alert system was developed as a part of a quality-improvement project for severe sepsis and septic shock. The tool used a combination of systemic inflammatory response syndrome and organ dysfunction (i.e. hypotension, hypoxemia, or lactic acidosis) criteria. We demonstrated that this electronic sepsis alert had a sensitivity of 93%, specificity of 98%, positive predictive value of 20%, and negative predictive value of 99.9% for severe sepsis and septic shock.[22] Implementation of the sepsis e-alert and sepsis response team was associated with a reduction in the time until the identification of severe sepsis and an increase in compliance with the sepsis resuscitation bundle. We should note that the diagnostic accuracy of screening electronic alert tool for severe sepsis and septic shock needs to be studied further as there are only few studies on this topic. In addition, the impact of such alerts on mortality is unclear and requires further studies.

The ICU is a highly complex healthcare setting with very sick patients supported with multiple devices and machines. Complex care inevitably requires measuring multiple parameters, carrying out multiple tests and prescribing multiple treatments. Table 3 displays an analysis of the quantity of data generated by patients in the first 24 h of admission to the ICU, (unpublished data from a sample of patients admitted to ICU at the Mayo Clinic, Rochester presented by Dr. Brian Pickering).

When faced with such large quantities of data, the human cognitive function becomes overwhelmed (information overload), and performance fails. The consequences of information overload for healthcare workers include: (1) Paralyzed decision-making, (2) failure to recognize emerging life-threatening emergencies, (3) communication failure, (4) delayed treatment initiation, and eventually (5) physician burnout.

Given the vulnerable nature of critically ill patients, the importance of timely interventions in the prevention of organ failure cannot be overstated. We know that delayed care leads to prolonged ICU and hospital length of stay and excess mortality. If information overload impairs physician performance, it can result in the most serious patient-centered complications.

A multipronged approach is required to solve this emerging patient safety concern. As healthcare has become more complex, IT systems have simply delivered more and more

Table 3: The load of data generated in a 24-bed ICU

	Average data points per day	
	Per patient	Per 24 bedded ICU
Laboratory	60	1440
Drug orders	10	240
Microbiology	2	48
X-ray	2	48
Vital signs	1950	46,800

ICU = Intensive Care Unit

information to healthcare workers resulting in information overload. In the same way as physicians need to summarize, simplify and package patient information to communicate effectively with other physicians and other healthcare workers, the CPOE systems of the future need to do the same. Key components of this IT approach to manage information overload include:

- Engaging with stakeholders (providers and patients) in the design and implementation of new CPOE interfaces for the ICU. Commercial vendors have limited access to clinical insights. They desperately need to engage with clinicians to develop better products for our patients. An added benefit of engagement from the clinical perspective is that of a greater understanding of the positive and negative ways IT impact on the quality of the work environment and patient outcomes
- Developing CPOE displays that adapt to the context in which they are operating and prioritize clinical information relevant to that context. This will increase the signal-to-noise ratio of data so that clinicians do not miss vital information
- A move away from thinking of a CPOE as a database. A future CPOE should display information as concepts. This is expected to reduce the cognitive burden of connecting the dots between pieces of information scattered across several databases in the electronic medical record, improve efficiency and facilitate less time with the computer
- Applying human-centered design principles to the design and integration of alerts into clinical environments to minimize disruption of workflow. This will lead to improving the real world efficacy of the clinical information systems and increase provider satisfaction with their environment.

IT has wide-ranging spectrum applications in patient safety in the acute care setting and, in particular, the ICU. CPOE and electronic alert systems are examples that have been shown to improve care delivery and probably outcomes. However, all IT applications can introduce substantial vulnerabilities. Information overload is a particular problem. Implementation of IT solutions as a tool for patient safety needs to take in account strategies to maximize the benefits from standardization and mitigate the drawbacks of information overload.

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