Will the impact of new information technology be Epic®? The effect of information technology on adverse drug events

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Abstract
In this review we discuss the influence of information technology in managing adverse drug events (ADE). Damage due to ADEs on patient care is high. There is different information technology measures which decrease ADEs significantly, major reductions in numbers were for medication errors. Please read through the article to see how information technologies influence prescribing, transcription, dispensing, administration, and monitoring processes.

Key words: ADE, Information Technology, patient safety

Introduction
The terms adverse drug reaction (ADR), adverse drug event (ADE), and medication error are commonly used, often interchangeably, in the healthcare setting, and these incidents can have a large impact on patient safety. The World Health Organization (WHO) defines an ADR to be “a response to a drug that is noxious and unintended and occurs at doses normally used in man for the prophylaxis, diagnosis or therapy of disease, or for modification of physiological function.” An ADE is an injury resulting from the use of a drug, and it includes medication errors and ADRs. The Food and Drug Administration (FDA) defines a medication error to be any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional, patient, or consumer. While there are subtle differences in the definitions of an ADR and an ADE, it is more pertinent to place an emphasis on the alarming rates at which they occur, despite the implementation of information technology.

It is estimated that ADRs are between the fourth and sixth leading cause of death, and the cost of treating patients who experience an ADR may be as high as $5 billion annually.
One study estimated that 3% to 9% of hospital admissions are due to preventable ADRs. An epidemiological review conducted by the Institute of Medicine (IOM) in 2004 demonstrated that at least 1.5 million patients are harmed by medications each year. At least 400,000 preventable ADEs occur in hospitals per year, which equates to approximately one medication error per patient per day. Based on this review, the IOM introduced several recommendations to prevent medication errors. One recommendation was that all healthcare organizations should supply providers with patient information and decision-support tools. They also recommended that prescribers should have plans to e-prescribe by 2008 and that all prescriptions should be both written by providers and received in pharmacies electronically by 2010. Obviously, these deadlines were not reached, but progress is being made. And yet, do these systems really improve patient safety and decrease adverse event rates? Evaluating the medication use process, and the errors that occur throughout this process, is a method that can be used to answer this question. The medication use process involves prescribing, transcribing, dispensing, administration, and monitoring. Figure 1 depicts these five steps and includes error rates within each, along with technology designed to reduce these errors.

### Prescribing
Errors in prescribing are most often a result of a lack of knowledge about the prescribed drug, lack of an established relationship with the patient, distractions, or calculation errors. These types of errors lead to approximately 39% of all medications errors. Computerized prescriber order entry (CPOE) is an important tool to help decrease the rate of prescribing errors.

Studies have evaluated the efficacy of CPOE at preventing medication errors in the prescribing process. A landmark trial completed in 1998 studied the effect of CPOE on the rate of ADRs in a large tertiary care hospital. Over a 6-month period, prior to implementation of CPOE, all admitted patients were stratified into a random sample in 6 medical and surgical units. After CPOE implementation, patients were stratified in a randomized sample in the same units, plus two additional units, for a period of 9 months. Non-intercepted serious medication errors decreased from 10.7 events to 4.68 events per 1000 patient days, which equates to a 55% reduction. Non-intercepted potential ADRs decreased 84%. Another study conducted to determine the effects of CPOE with decision support, such as drug allergy or drug-drug interaction warnings, found that this technology decreased non-missed dose medication errors by 81%. This evidence shows that CPOE will decrease medication error rates to some extent, but these
studies were conducted after complete implementation of the technology. Therefore, questions remain about rates during, and immediately after, the implementation process.

As with any new policy or procedure, an initial increase in error may be expected as staff adjusts to the new technology. One study characterized CPOE-related factors that may increase the risk of prescribing errors and classified errors as information errors (e.g., reliance on CPOE for usual doses) or human-machine interface flaws (e.g., incorrect medication selection).\(^2\) A study conducted in 2007 in a neurosurgical intensive care unit (ICU) found an increase in medication errors from 0.938 per 1000 doses pre-CPOE to 1.839 medication errors per 1000 doses during the month of CPOE implementation. This increase in errors was not found to cause an increase in patient harm.\(^{13}\) This study highlights the need for continued education of hospital staff, before, during, and after CPOE implementation.

Another technological tool used during prescribing is clinical decision support (CDS), which is usually employed in conjunction with CPOE, but may be used alone as well. These systems provide varying levels of support to providers, from assisting with drug selection and dosing to integrating patient-specific data into the decision.\(^{14}\) Several studies have evaluated the ability of CDS to reduce medication errors and ADEs. It has been demonstrated that susceptibility to an antimicrobial regimen can be increased with the use of CDS. These support systems also demonstrated the capacity to assist in reducing ADEs caused by antibiotics and in decreasing the rates of toxicity of aminoglycosides.\(^{14}\) Another study that investigated the use of CDS found a decrease of 81% and 86% in medication errors and serious non-intercepted medication errors, respectively.\(^2\) Overall, numerous studies demonstrate the benefit of using CDS, with or without CPOE, in reducing medication errors.

**Transcribing**

Transcription errors, which are often a result of illegible handwriting, leading or trailing zeros, and abbreviations, can also be prevented with the use of CPOE.\(^5\) Additionally, other technology can be implemented to reduce transcription errors. Medication administration records allow for clinicians to document the administration of medications, and electronic medication administration records (eMAR) facilitate a more efficient process by nurses and help to reduce medication errors.\(^2,9,14\) One study evaluated the use of CPOE with and without eMAR and determined that the use of eMAR decreased the transcription errors to zero and reduced the time until medications were administered.\(^2\) The limited data that are published on the use of eMAR suggests that it helps to reduce errors associated with transcription, especially when used in combination with CPOE.

**Dispensing**

The next step in the medication use process after transcription is dispensing. Automated dispensing devices, such as robots, allow for increased accuracy in the dispensing of
medications. Recognizing medication bar codes is one task of an automated robot that may help to reduce dispensing errors. In one study completed on adults in an inpatient facility, dispensing errors decreased from 2.9% to 0.6% with the use of a robot. 

Bar codes, which can be used in conjunction with automated dispensing devices, require both the patient and the medication to have a unique bar code identifier. The nurse must scan the medication to be administered, and the bar code on the patient’s wrist bracelet confirms the medication is correct and intended for the specific patient. Dispensing errors should be greatly reduced if each medication in the pharmacy had a barcode, as this would ensure the correct medication, strength, and formulation was dispensed. One study found that the use of bar codes decreased wrong medication errors, wrong dose errors, wrong formulation errors, and expired medication errors, as well as reducing potential ADRs by more than 60%.

Administration
Bar codes not only help to decrease dispensing errors, but are also effective in the administration process. Once a medication reaches a patient’s bedside, there are few ways to prevent medication errors. One study determined that, while 48% of ordering errors were intercepted prior to reaching the patient’s bedside, zero administration errors were intercepted before reaching the patient. Bar codes may help in this area, as previously mentioned. Smart infusion pumps are another mechanism to reduce administration errors. The alerts and drug library are inherent features of the smart pumps, and compliance with these is essential to the successful implementation of this technology.

Monitoring
Monitoring the effectiveness of these technology systems is crucial to the continual improvement of patient safety. Chart reviews and/or spontaneous reporting can be used to detect ADEs, but these are associated with some limitations; spontaneous reporting does not capture a large number of events and chart review is expensive. Therefore, computerized ADE monitoring can be used to identify ADEs that occur, to help further analyze and improve systems processes in place. In one evaluation of a computerized ADE monitoring system, a total of 617 ADEs were identified by the computerized method, voluntary reporting, and/or chart review (some ADEs were identified by more than 1 method). Of these 617 ADEs, 45%, 65% and 4% were detected by computerized monitoring, chart review, and voluntary reporting, respectively. According to this assessment, chart review captured a larger percentage of the ADEs that occurred, but it also required approximately 5 times the number of hours compared with computer monitoring. Only a small number (75) of ADEs were identified by both chart review and computer monitoring, which suggests that both methods may be important in detecting all ADEs that occur.
In summary, ADRs have decreased with the implementation of new technology, as demonstrated by the evidence reviewed in this article. These studies emphasize how technology that may be taken for granted can be used to reduce medication errors - errors that are closely related to ADRs and have the potential to cause patient harm. Thus, every effort should be made to reduce these errors. As technology continues to improve, healthcare must also evolve to improve patient safety and care.

References