

normal mental slips and lapses in memory, but recognize that enhancing safety system design through the use of technology is an invaluable tool in the prevention of potentially life-threatening mistakes. Estimates on the financial impact of adverse drug events (ADEs) attribute \$2 billion of increased hospitalization costs to preventable ADEs (Adachi & Lodolce, 2005). The 2006 IOM report, *Preventing Medication Errors*, noted that to deliver safe drug care, healthcare organizations should make effective use of well-designed technologies, which will vary by setting. Although the evidence for this assertion is strongest in the inpatient setting, the use of technology will undoubtedly lead to major improvements in all settings (Aspden, Wolcott, Bootman, & Cronenwett, 2006). In 2009, the American Recovery and Reinvestment Act (ARRA) invested \$25.8 billion into healthcare to incentivize the adoption, standardization, and meaningful use of health information technology (S1, 2009).

TECHNOLOGY AND HEALTHCARE

In the past, the majority of technology acquisitions have consisted of basic stand-alone computer systems, which were primarily used for data input to increase each department's efficiency with financial accountability measures. These computers were generally installed in the pharmacy, radiology, and laboratory departments, and could also be found in the administration and business offices. Each department was allowed to evaluate and purchase their own unique computer system, preventing any integration of data or dissemination of critical patient information, which is indispensable in providing safe care (Leape et al., 1995). But even as improving technologies have emerged allowing for seamless integration of information to occur, organizations are challenged with the huge costs associated with replacing their non-integrated computer systems. According to an American Society of Health-System Pharmacists (ASHP) survey in 2011, 66.7% of the responding hospitals stated that they had the components of an electronic medical record (EMR), but completely digital hospitals with fully implemented EMRs is far in the future, considering only 8% of hospitals were fully digital (without paper records). An estimated 34.2% of hospitals were using computerized prescriber order entry systems (CPOE) with decision support, 50.2% use barcode medication administration, and 67.9% were using intelligent infusion devices (smart pumps) (Pedersen, Schneider, & Scheckelhoff, 2011).

INFLUENCES ON THE ADOPTION

media reporting of medical mistakes, which have resulted in patient harm and deaths. In 1995, there were television and newspaper accounts that reported the tragic death of a patient from a preventable ADE due to an inadvertent administration of a massive overdose of a chemotherapy agent over four days. This particular error became a watershed event for patients, practitioners, and healthcare organizations alike, not only because it occurred at the world renowned Dana Farber Cancer Institute, but also because it happened to the prestigious *Boston Globe* healthcare reporter, Betsy Lehman. How could a mistake of this proportion occur in a leading healthcare facility where each practitioner is specifically educated in the care and treatment of cancer patients? A root cause analysis of the error revealed that there was no malpractice or egregious behavior, but that excellent, conscientious, and caring pharmacists and nurses simply interpreted an ambiguous handwritten chemotherapy order incorrectly. In retrospect, if technology had been available, the physician could have entered the medication order into a CPOE system and this heartbreaking error may not have happened.

Unfortunately, this example is by far not an isolated case. According to a 1994 American Medical Association report, medication errors related to the misinterpretation of physicians' prescriptions were the second most prevalent and expensive claim listed on malpractice cases filed over a seven-year period on 90,000 malpractice claims between 1985 and 1992 (Cabral, 1997). Also, it has been estimated in the outpatient setting that indecipherable or unclear orders resulted in more than 150 million telephone calls from pharmacists and nurses to prescribers requiring clarification, which not only is time consuming for practitioners, but estimated to cost healthcare systems billions of dollars each year. Thus, the availability of critical clinical information needed at the point of care (during prescribing, dispensing, and administering) can not only improve time management and contribute to cost savings through improved utilization of medications, staff and patient satisfaction, but most importantly, reduce the incidence of error.

The first organized attempt to move acute care organizations toward improving patient safety through technology began from an initiative by The Leapfrog Group. Composed of more than 150 private and public organizations providing healthcare benefits, this group felt that they had a significant financial investment in preventing errors for their employees, thus increasing productivity by contracting only with those organizations that had hospital-wide adoption of CPOE technology. Yet, a survey by Leapfrog completed in 2003 showed that not only did this financial incentive result in no increase from the 2002

(Stefanacci, 2004). According to Leapfrog, 26% of the 1244 hospitals that completed their survey in 2009 report having a CPOE system in at least one inpatient department (Leapfrog, 2010). Even if an organization implements CPOE, this does not mean that the system will catch incorrect medication orders entered into the system. Another report from Leapfrog, based on a study between June 2008 and January 2010 of 214 hospitals from across the United States who completed Leapfrog's CPOE evaluation tool, revealed that these systems potentially missed half of the routine medication orders and one-third of potentially fatal medication orders (Leapfrog). Because little research is available on the effectiveness of CPOE on medication error prevention, other organizations such as the Joint Commission, a non-profit organization that is the nation's leading standards-setting and accrediting body in healthcare, and the National Quality Forum (NQF) are presently refraining from uniformly requiring its adoption.

Probably the most important development to promote the implementation of technology is the announcement by the Centers for Medicare & Medicaid Services (CMS) of a proposed rule to implement provisions of the American Recovery and Reinvestment Act of 2009 (Recovery Act) that provide incentive payments for the meaningful use of certified electronic health records (EHR) technology. The Medicare EHR incentive program will provide incentive payments to eligible professionals, eligible hospitals, and critical access hospitals that are meaningful users of certified EHR technology. The Medicaid EHR incentive program will provide incentive payments to eligible professionals and hospitals for efforts to adopt, implement, or upgrade certified EHR technology or for meaningful use in the first year of their participation in the program and for demonstrating meaningful use during each of five subsequent years (CMS, 2010).

Interest in the use of barcoding technology increased due to the Food and Drug Administration's (FDA's) February 25, 2004 ruling, which required medications to have machine-readable barcodes. In an optimally acute care, barcoded environment, a nurse would scan his or her barcode identification badge at the beginning of each medication administration time, the patient's barcode identification band, and the intended drug's barcoded label with a barcode scanner. A mismatch between the patient, the drug packaging applied during manufacturing/repackaging, an incorrect time, dose or route, and the patient's medication record would trigger a warning, prompting the nurse to investigate the discrepancy before administering the medication. One of the first healthcare facilities to adopt barcode technology was due to the incentive provided by the federal government

wrong medications being administered, a 57% improvement in errors caused by incorrect doses being administered, a 91% improvement in wrong patient errors, and almost a 92% improvement in wrong time errors between 1993 and 1999. Additional examples of evolving technology used to prevent medication errors include automated dispensing cabinets (ADCs) and smart infusion pumps. As more technology systems are introduced into healthcare, it is important that nurses understand their benefits and problems, and how technology will affect their practice. As noted by the IOM report, *Keeping Patients Safe: Transforming the Work Environment of Nurses*, despite its potential, patient safety experts caution that technology by itself is not a panacea. While able to remedy some problems, technology may also generate new forms of error and failure (Institute of Medicine, 2004).

Computerized Prescriber Order Entry (CPOE)

To a large degree, healthcare practitioners still communicate information in the "old-fashioned way." According to the aforementioned ASHP technology survey, 34.2% of U.S. hospitals had a CPOE system in 2011, which was a 45% increase from the preceding year. The survey showed that more larger hospitals had a CPOE system compared to smaller hospitals (Pedersen et al., 2011).

Many factors demonstrate the need for a shift from a traditional paper-based system that relies on the practitioners' vigilance to automated order entry, record keeping, and clinical care. These factors include accessing patient information spread across multiple organizations that may be unavailable, especially in large organizations and, therefore, medical care would be provided without pertinent patient information. The structure of the patient's record often makes it difficult to locate valuable information as well as illegible handwritten entries by healthcare practitioners, and for those patients with chronic or complex conditions, the records can increase to multiple volumes over many years. These problems result in a variety of communication breakdowns when providing healthcare to patients from the duplication of services, delays in treatment, increased length of stay, and increased risk of medical errors. Additionally, human memory-based medicine can be inaccurate or not recalled.

There are also many barriers that lead to ineffective communication of medication orders that include issues with illegible handwriting, use of dangerous abbreviations and dose designations, and verbal and faxed orders. Studies have shown that as a result of poor handwriting, 50% of all written physician orders require extra time