filtered patient information to clinicians and/or patients for the purpose of improving healthcare processes and outcomes. CDS includes knowledge-delivery interventions, such as targeted documentation forms and templates, relevant data presentation, order and prescription creation facilitators, protocol and pathway support, reference information and guidance, and alerts and reminders (Osheroff, 2009).

The Leapfrog CPOE evaluation tool has been promoted as a means of monitoring the efficacy of hospitals systems and their CDS. Results from a study designed to determine the relationship between Leapfrog scores and the rates of preventable ADEs and potential ADEs indicated that scores from the Leapfrog CPOE evaluation tool closely relate to actual rates of preventable ADEs and that Leapfrog testing may alert providers to potential vulnerabilities and highlight areas for further improvement (Leung et al., 2013).

A study by Nebeker and colleagues showed that high rates of ADEs may continue after CPOE implementation if the system lacks CDS for drug selection, dosing, and monitoring (Nebeker, Hoffman, Weir, Bennett, & Hurdleet, 2005). Studies have shown those prescribers, using only the basic CPOE system alone, order appropriate medication doses for patients 54% of the time. By comparison, prescribers using the CPOE system with decision support tools prescribed appropriate doses 67% of the time. The addition of the decision support tools also increased the percentage of prescriptions considered ordered at appropriate intervals to 59%, from 35% with the basic CPOE system (Kaushal et al., 2001). A national sample of 62 hospitals voluntarily used a simulation tool designed to assess how well safety decision support worked when applied to medication orders in computerized order entry. This simulation detected only 53% of the medication orders that would have resulted in fatalities and 10% to 82% of the test orders that would have caused serious adverse drug events (Metzger, Welebob, Bates, Lipsitz, & Classen, 2010).

Complex and time-consuming order entry processes can often lead to practitioner frustration as evidenced by potential increases in the use of verbal orders, another error-prone process in communicating medication orders. Computer issues such as error messages, frozen screens, slow access to information, and other issues lead to problems of accessing critical patient or drug information as well as adding to prescriber frustration. It is important to have the ability to access past patient histories, particularly previous ADEs and comorbid conditions, yet some systems are unable to access prior patient care encounters. Problems may arise if drug information updates are not performed on a timely basis or if this information is difficult to access. One key error reduction strategy is the ability to install user-defined warnings (e.g., "look-alike/sound-alike" drug name alert), yet some systems do not allow for this type of customization.

New types of medication errors can occur with the use of CPOE such as wrong patient errors, when the wrong patient is selected from a menu list of similar patient names; wrong drug errors, when the wrong medication is selected from a list due to look-alike similarity in either the brand or generic name; or orders intended for laboratory levels that are filled as medications. In a study that compared the manifestations, mechanisms, and rates of system-related errors associated with two electronic prescribing systems showed that 27.4% of system-related errors manifested as timing errors, 22.5% wrong drug strength errors, and selection errors accounted for 43.4% (34.2/100 admissions) (Westbrook et al., 2013). Another study that attempted to quantify the frequency and analyze risk factors for patient mis-selection errors when entering orders revealed many contributing factors, including similarly spelled last names when picking patient names from a list, having multiple charts opened at the same time, and distractions (Levin, Levin, & Docimo, 2012).

Even though CPOE systems are intended for use by prescribers, their presence in organizations will affect nursing and other personnel as well. CPOE systems will affect or even change the work of nurses in many ways, both negative and positive (AHA, 2000). First, like pre- scribers, these systems will require nurses to possess basi computer skills. Depending on the design of the system nurses may find it difficult to know when new orde have been entered into the system, a special concern wi respect to "STAT" or other new orders. Nurses sometim see off-site entry of orders by prescribers as detriment because it reduces the opportunity to communicate inf mation or ask questions face-to-face with prescribers w regard to the care of patients. In some situations, presc ers are reluctant to enter orders and use verbal order a way of "getting around" entering orders into the C system and, in fact, nurses may end up entering v orders from prescribers.

But there are many beneficial aspects of these sys for nurses. Providing the capability for computerized sician order entry and making patient education ma available electronically to nurses also have been ide as strategies to facilitate communication. With com ized physician order entry, nurses do not have to in transcription or verification of orders. Electronic education materials, unlike printed materials, ar modifiable to meet clinician and patient needs; it is sible to track which materials were given and by who follow-up and comprehension, and link educatio ties and documentation (Case, Mowry, & Welebo

Nurses may have more time with patients due to enhanced productivity due to a reduced frequency in contacting prescribers to clarify orders. Additionally, there would be reductions in time wasted in transcribing duplicate orders for the same medication or test; greater standardization of orders, lessening the need to understand and adhere to diverse regimens and schedules; improved efficiency when ordering tests or procedures, thus reducing time devoted to carrying out redundant orders; and less need to enter voice orders into the system as prescribers gain access to the system from other units and remote locations. Finally, orders would be usually executed faster, medications would be available more quickly, and patients receive care more promptly. It is important for healthcare administration and nurses to understand that for a CPOE system to work as intended, it must be fully utilized by prescribers.

Barcode-Assisted Medication Administration (BCMA)

Nurses play a vital role in the medication-use process, ranging from their involvement in the communication of medication orders to the administration of medications. As nurses know well, the administration of medications can be a labor-intensive and error-prone process. One study showed that 38% of medication errors occur during the drug administration process (Leape et al., 1995). While about half of the ordering, transcribing, and dispensing errors were intercepted by the nurse before the medication error reached the patient, almost none of the errors at the medication administration stage were caught. In another study of medication administration errors in 36 healthcare facilities, Barker et al. found that some type of medication administration error occurred in almost 20% of medication doses administered (Barker, Flynn, Pepper, Bates, & Mikeal, 2002). In addition, nurses are burdened with larger patient loads and are caring for patients with higher degrees of acuity than ever before. To make matters worse, the number of medications that have reached the market has grown 500% over the past 10 years to more than 17,000 trademarked and generic drugs in North America (Institute for Safe Medication Practices [ISMP], 2000). Rapid advances in technology have helped make this process more efficient and safe. One form of technology that will have a great impact on medication safety during the administration process is barcode-assisted medication administration (BCMA) technology.

For more than 20 years, barcode technology has clearly demonstrated its power to greatly improve productivity and accuracy in the identification of products in a variety of business settings, such as supermarkets and department stores. Proven to be an effective technology, it quickly spread to virtually all other industries. Yet, many organizations in the healthcare industry have not fully embraced this valuable technology as a method to enhance patient safety.

The 2011 ASHP National Survey reported that approximately 50% of hospitals stated using barcode technology (Pedersen et al., 2011). This number has increased significantly over the past year, with implementation rates improving by 45%. This survey showed that all Veterans Affairs hospitals used BCMA, and general and children's medical-surgical hospitals with 100 to 399 beds were more likely to have BCMA to verify the accuracy of medication administration at the point of care. The reasons for these few numbers are varied and may include the cost of implementation, challenges integrating with current informatics systems, and prioritization among other information technology projects. The survey also revealed that larger hospitals (400 or more staff beds) had adopted CPOE before starting to adopt BCMA.

For the healthcare industry, the potential effect of implementing barcode technology to improve the safe administration of medications is enormous. As previously stated, the VA Healthcare System, a pioneer in the use of barcode technology, looked at their medication error rate based on the number of incident reports related to medication errors before and after implementation of the BCMA system. The study showed that following the introduction of the BCMA, reported medication error rates declined from 0.02% per dose administered to 0.0025%. This is almost a 10-fold reduction in errors over eight years (Johnson, Carlson, Tucker, & Willette, 2002). In a study that used the direct-observation methodology to monitor medication administration before and after the deployment of electronic medication administration records (eMARs) and BCMA systems showed a 54% reduction of medication administration errors (Paoletti et al., 2007). In another study that assessed rates of errors in order transcription and medication administration on units before and after implementation of the BCMA, observers noted an 11.5% error rate in medication administration on units that did not use the BCMA versus a 6.8% error rate on units that did use it—a 41.4% relative reduction in errors. The rate of potential ADEs (other than those associated with timing errors) fell from 3.1% without the use of the BCMA to 1.6% with its use, representing a 50.8% relative reduction (Poon et al., 2010). Procedural areas and emergency departments (EDs) are oftentimes excluded from the implementation of BCMA systems due to distinct differences from typical patient care areas. One recent study showed that, in addition to being feasible, the implementation of a BCMA system was associated with a relative