Preventing medication errors: A summary

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Starting in 2000, the Institute of Medicine (IOM) began publishing a remarkably successful series of reports on quality in healthcare. *To Err is Human* brought the problem of medical safety into public awareness.1 *Crossing the Quality Chasm* made four major points: errors are common and costly, systems cause errors, errors can be prevented and safety can be improved, and medication-related adverse events are the single leading cause of injury.2 Even more importantly, the report suggested that between the healthcare that exists today and the healthcare that is possible lies not just a gap but a chasm, and it attempted to provide a blueprint for how that chasm might be crossed.2 That has not yet been accomplished, yet progress is being made. The most recent report, *Preventing Medication Errors*, is an attempt to think about what needs to be done to reach the next level of medication safety.3

The work underlying *Preventing Medication Errors* began in 2004 when Congress mandated the Center for Medicare and Medicaid Services (CMS) to sponsor the IOM to conduct a comprehensive study of drug safety and quality issues in order to provide a blueprint for system-wide change. First, an epidemiological review showed that, estimated very conservatively, medications harm at least 1.5 million people per year. In hospitals, there are at least 400,000 preventable adverse drug events (ADEs) per year, or approximately one medication error per patient per day. That finding probably had the greatest impact on the general public.3

**IOM recommendations**

The IOM report's recommendations are summarized in Table 1.3 The emphasis on the patient is...
evident throughout the report, especially in Recommendation 1. Recommendation 2 reflects the feeling that the resource base for consumer-oriented drug information today is not adequate. Providers today do not necessarily have access to comprehensive reference information when they are delivering care, yet this is vitally important.

Recommendation 3 emphasizes the need to communicate patient-specific medication information “interoperatively,” i.e., so that it can be moved from one clinical setting

### Table 1. Preventing Medication Errors recommendations

<table>
<thead>
<tr>
<th>Recommendation 1</th>
<th>To improve the quality and safety of the medication use process, specific measures should be instituted to strengthen patients’ capacities for sound medication self-management.</th>
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<td>• Patients’ rights should be formalized.</td>
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<td>• Patients should maintain an active list to which all providers should have access.</td>
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<td>• Providers should educate patients about their medications.</td>
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<td>• Consultation on medications should be available to patients at key points in the medication use process, e.g., when a patient is admitted and discharged and receives medication at a pharmacy.</td>
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**Recommendation 2.** Government agencies (Agency for Healthcare Research and Quality [AHRQ], CMS, the Food and Drug Administration [FDA]) should enhance the resource base for consumer-oriented drug information and medication of self-management support.

- Pharmacy leaflets should be standardized.
- The National Library of Medicine (NLM) should be chief internet resource for consumers.
- FDA, CMS, and NLM should evaluate approaches for building a national network of drug information help-lines.
- Same group should confirm minimum dataset for public health records (PHRs).
- National plan for widespread distribution of medication safety information should be developed.

**Recommendation 3.** All healthcare organizations should make available to providers patient information and decision-support tools to enable providers to:

- Access comprehensive reference information,
- Communicate patient-specific medication information interoperably,
- Assess safety through active monitoring,
- By 2008, prescribers should have plans in place to e-prescribe and by 2010 write all and have pharmacies receive all electronically,
- Subject prescriptions to decision support,
- Have the appropriate competencies for the medication use process,
- Make effective use of technologies, which will vary by setting.

**Recommendation 4.** Better labeling is needed, as are better methods for communicating medication information to consumers.

- FDA should develop guidance documents to industry for labeling and packaging.
- Studies about design of labeling and information sheets should be done.
- FDA should work with industry to develop a strategy for expanding unit-of-use packaging.
- AHRQ should fund studies evaluating impact of samples on safety, prescribing behavior, and consumer choice.

**Recommendation 5.** Industry and government should collaborate to establish standards affecting drug-related healthcare information technology (HIT):

- NLM and drug nomenclature
- AHRQ and safety alert mechanisms by severity, frequency, and clinical importance, including
  - Intelligent prompting
  - Human factors
  - Specifications for alerts.

**Recommendation 6.** Congress should fund AHRQ to work with other agencies to develop a broad research agenda on safe and appropriate medication use, especially testing of error prevention strategies:

- Annual level of investment $100 million [Current levels of investment are approaching zero].

**Recommendation 7.** Oversight and regulatory organizations and payers should use [tactics] to motivate the adoption of practices that can reduce medication errors and ensure that providers have needed competencies.

- Payers and purchasers should provide explicit financial incentives.
- CMS should evaluate a variety of strategies for medication therapy management.
- Regulators should set minimum functionality standards for error prevention technologies.
- States should enable e-prescribing.
- State boards of pharmacy should undertake quality improvement (QI) initiatives related to community pharmacy practice.
- Medication error reporting should be promoted by all.
-Accreditors of professional education should require more training in medication-related areas.
to another. It should be possible, for example, for a patient to go from New York to Louisiana and still have the important medication information be accessible.

Safety needs to be assessed through active monitoring. Today there is far too much reliance on spontaneous monitoring, which does not provide a solid sense of the magnitude of the problem in terms of medication safety.

By 2008 prescribers should have plans in place to “e-prescribe” and by 2010 to write all, and have pharmacies receive all, prescriptions electronically. This is one of the most important recommendations in the report and is eminently achievable if the healthcare community focuses strongly on this goal and addresses the key policy issues surrounding it.

Another critical point is that prescriptions need to be subjected to decision support that is more robust and standardized than it is today. In addition, all providers in the medication-use process need to have the appropriate competencies. For example, prescribers of oncology medications and pharmacists performing medication order reviews on oncology drugs need to have appropriate competencies to perform these tasks. In addition, providers need to make effective use of technologies.

Recommendation 4 states that AHRQ should fund studies evaluating the impact of samples on safety, prescribing behavior, and consumer choice. Some of the committee members wanted to recommend that samples should just be eliminated.

Recommendation 5 was to establish standards for drug-related healthcare information technology (HIT), which is essential to achieve the next level of safety. The National Library of Medicine (NLM) is already working on drug nomenclature but needs more support to finish this work. A standard way of representing drugs that can be used by everyone is still not available. This is remarkable, since standards are fairly robust in many other areas, such as for laboratory tests and imaging.

AHRQ should evaluate safety alert mechanisms and include issues, such as intelligent prompting, human factors, and specifications for specific types of alerts. Finally, much of the benefit to be gained in medication safety will come from having good decision support, which is not currently standardized in the systems in use.

Recommendation 6 was for an annual investment of approximately $100 million to fund AHRQ to work with other agencies to develop a broad research agenda on safe and appropriate medication use. Current levels of investment on research on patient safety broadly are approaching zero, except for issues relating to safety and health information technology. The money that AHRQ has to spend on patient safety in 2007 will all be spent on safety outside the hospital. More balance is needed.

Recommendation 7, the policy recommendation calls for payers and purchasers to provide explicit financial incentives for doing things that improve medication safety. Financial incentives are being implemented, yet this is still in the very early stages. Many states have proposed legislation on e-prescribing that is starting to be passed, yet approximately 20 states have problems with this (e.g., electronic signatures are not permitted). Such problems need to be eliminated.

Recommendations to pharmacy (Table 2) included the need to monitor the frequencies of errors and near-misses, so that corrections can be made. Today many pharmacies rely on spontaneous reporting. If interventions are made, it is important to track those interventions and use prescribing errors corrected by pharmacists as opportunities to identify areas for improvement.

Pharmacists should report errors to external reporting programs, so that organizations such as the Institute for Safe Medication Practices (ISMP) can identify patterns and widespread problems. It is also recommended that pharmacists verify patient identity, use bar codes, and educate consumers about error prevention. Consumer education is an important issue. All too often, when patients receive their medications at a drug store, they merely take the packaged medications and move on without learning how to take them properly.

The next set of recommendations reinforces the need to ensure that prescribing is electronic and that the prescriptions are going directly to the pharmacies. Also, trivial warnings from decision-support systems need to be suppressed. The final set of recommendations for individual pharmacists emphasized the need for repeated reviews and discussions at key points in the medication-use process, particularly upon admission and at discharge.

Computerized prescriber order entry

A 1998 study identified a 55% reduction in the serious medication error rate following the implementation of computerized prescribing—even a system with very limited physician support. There was an 83% reduction in the overall medication error rate. The cost of each preventable ADE was about $6000.

Renal insufficiency. More recent studies have identified the results that can be obtained if decision support is added to computerized prescriber order entry (CPOE). One of the most important types of decision support is renal dosing decision support. The 2001 “Nephros” study evaluated the impact of delivering real-time decision support for patients with renal insufficiency and found significant benefit. The findings showed that a large number of patients (42% of 17,828) had some degree of renal insufficiency. There are several hun-

dried drugs whose doses require adjustment for renal insufficiency. Remembering all these doses correctly exceeds the scope of any individual’s capabilities. The Nephros results showed that in the control group the prescribed dose was correct only 54% of the time, and the frequency only 35% of the time. In the intervention group, correct dose and frequency increased to 67% and 59%, respectively, and patients’ length of stay decreased by about a half-day.9 Financial analyses of the impact of decision support implementation also showed this to be one of the more important interventions.

**Geriatric patients.** Another study looked at the impact of decision support on prescribing for geriatric inpatients.7 Elderly patients frequently get dosages that are too high, especially initial dosages. A randomized controlled trial with decision support for dosing of psychoactive drugs found that when prescribing suggestions were made, patients more often got the recommended dose (29% versus 19%). Most importantly, the rate at which patients fell decreased to 2.8 from 6.4 falls/1000 patient days. Nonetheless, the frequency with which people accepted the suggestions was still only 29% after the implementation of decision support. Thus, the results showed that it is clearly beneficial to suggest starting with a lower dosage, yet there is room for more improvement.7

**Meta-analysis.** A recent systematic review of the impact of CPOE on medication safety showed that of the five trials published at that time, two showed a marked decrease in the serious medication error rate, one showed improvement in the corollary order rate, one showed improvement in five prescribing behaviors, and one showed improvement in nephrotoxic drug dosing and frequency.8 Several additional studies are currently underway.

**Unintended consequences.** Several recent studies discussed in the IOM report have been quite controversial. A study by Koppel et al.9 evaluated the commercial CPOE application at the University of Pennsylvania and asked users their impressions about the system. They found many situations in which “a leading CPOE system” facilitated medication error risks. They also found that it often took many screens to do things that people needed to do routinely, and that some needed screen views were not available.9 It is important to note that others have also reported on this issue.10

The Koppel study had a few issues.9,11 First, errors or adverse events were not actually counted. Second, the investigators said that other studies focused only on the advantages of CPOE, which is not accurate. In fact, previous studies actually evaluated how many errors were made before the implementation of order entry, how many occurred afterwards, and the difference. Our studies included the errors that were created by the system. Anytime you introduce a new system, it does cause some new errors. Third, the CPOE application that they studied was an old one.11 Nonetheless, valuable debate was stimulated and some key points identified from this published review. The first is that after a CPOE system is implemented, iterative changes have to be made. A system should not be installed and then left alone. At one time or another our institution experienced essentially all the problems reported on by Koppel et al.,9 yet following implementation serial changes were made to address those problems. The second point is that software alone is insufficient; people systems as well as software systems must be addressed.11

**Pediatric transfer patients.** Perhaps more troublesome study from the University of Pittsburgh looked at children who were transported in special care.12 In that study the mortality rate increased from 2.8% to 6.3% after the introduction of a commercial CPOE application.12

Some caveats regarding these findings: first, the study design was before/after, and a number of other changes were made at the same time CPOE was implemented, making it difficult to assess the impact of CPOE.
alone; overall mortality was not reported; and CPOE was introduced very rapidly—over only six days. There are various ways to implement CPOE, and rapid implementation has some advantages, since parallel systems do not exist. Nonetheless, CPOE implementation is a substantial systems change. At Brigham and Women’s, CPOE was introduced over approximately three years.

Moreover, after CPOE implementation, order entry was not allowed until the patient had actually entered the hospital and been logged into the system. The pediatric patients evaluated were those who were being transported in for special care because they were very sick; many were coming in by helicopter or ambulances. The previous approach was to have the house officer write the orders while the child was en route, so that everything would be ready and the pharmacy would have the drugs prepared when the child came through the door.12,13

Another issue was that after CPOE implementation, all the drugs, including the vasoactive drugs that many of these children needed, were moved to the central pharmacy, which was located away from the acute unit. A rule was implemented that said pharmacy was not allowed to process medication orders until after the orders were activated, which could not happen until the child had physically entered the institution. In addition, the decision was made to move ahead with implementation without putting in order sets. This has had a significant impact because groups of orders can be written much more quickly. Writing single orders on the computer is always slower. The net result was substantial delays in care delivery, which may have resulted in the differences seen before and after the implementation of CPOE.13

This study was quite weak methodologically. Nonetheless, the increase in mortality rate was very large and of obvious concern. Clearly, the organization broke many of the rules for implementation, and it is absolutely essential for other organizations that are implementing CPOE to handle the socio-technical aspects of implementation better.15

**Intravenous infusion safety systems**

Another very important technology is intravenous (i.v.) infusion safety systems. These so-called “smart pumps” are important because few administration errors get caught. If a doctor makes an error in prescribing, a pharmacist is going to review it, a nurse is going to review it, and there is a good chance the error will be intercepted before it gets to a patient. But with an administration error, there is no one between the nurse and the patient to intercept the error.

Intravenous errors can be especially dangerous. A significant error with a drug such as heparin or insulin can be catastrophic. For example, a physician ordered a heparin bolus dose of 4,000 units to be followed by an infusion of 890 units per hour.14 In this case, the 4,000 unit bolus dose was given appropriately, but the nurse misinterpreted the order and programmed the infusion device to deliver 4,000 units per hour and not 890 units per hour for continuous infusion. In this instance, the smart pump alerted the nurse.14 This is the kind of error that anyone could make at any time. Most of the time clinician errors have little consequence, but this kind of error could be fatal.

A study published in 2005 evaluated the impact of an early-generation device that was studied in the cardiac surgical intensive care units (ICU) and step-down units.15 In the control periods the alerts were turned off, and in the intervention periods the alerts were turned on. The evaluation was a time-series study, and the incidence of errors was found by chart abstraction and log reports. As shown in Figure 1, the results showed basically no difference in the preventable ADE rate between the control and the intervention groups or in the nonintercepted potential ADE rate, i.e., the “near miss” rate, which is where a benefit had been expected to be found. However, the ideal world projections, in which nurses actually would use the drug library and not override warnings, showed that i.v. infusion safety systems could have prevented a large number of preventable and potential ADEs.15

This study had several issues. First, the pumps were initially set up so that nurses could either use the drug library or not use the drug library, and many times they ended up not using it, especially in conditions when risky drugs were being used. Second, when nurses did get important warnings, they often ignored the warnings and overrode the alerts. Such overrides were more extensive than investigators had anticipated.15

The study led to several factors being identified, both from the study data and from information from Taxis.16 One issue is that unstable patients at times need drugs quickly, and time demands result in increased workloads that can lead to shortcuts and override violations. In addition, there was clearly an issue of lack of perceived risk. Nurses did not believe that what they were doing was associated with any real risk. There also may have been issues with role-modeling: no feedback was provided to the nurses during the study, and there were no forcing functions built into pump use at the time when the study was done.

The study clearly showed that serious i.v. infusion errors were frequent and could be detected using smart pumps.14 Prior to this study the magnitude of the problem was not well known, and at our institution we had little idea how common these errors were. Poor compliance was probably the main reason why the study did not show that smart pump use had
any impact on the serious medication error rate or the preventable ADE rate. This suggests that behavioral and technological factors have to be addressed if smart pumps are to achieve their potential for improving medication safety. Of note, this was a first-generation smart pump, and many improvements have subsequently been made, including a number based on these results.

Another study looked at the variation in infusion therapy practice in 100 hospitals. The results revealed unexpected, extensive variation in practice, much of which is quite clearly unnecessary and represents a safety risk. An analysis of smart pump drug libraries showed an average of 84 drugs per hospital, with an average of 8.5 names per drug across hospitals. The use of 8.5 different names for the same drug clearly has the potential to cause confusion during pump programming. The continuous dosing units used for the same drug also showed significant variability. These findings suggested that there is very substantial room for improvement, if hospitals will work together to standardize i.v. infusion practices across units and even across hospitals. A “toolkit” made available by the San Diego Patient Safety Consortium reports how this can be accomplished. Reaching consensus on infusion practices can be challenging, but standardization holds significant promise to improve infusion safety and quality of care.

Dispensing errors and bar coding
More recent studies have focused on dispensing errors, which are relatively common in hospital pharmacies because of the high volume of medications dispensed. More than 44,000 errors occur annually in a 735-bed hospital that dispenses about 6 million doses per year. Of these, investigators estimated that more than 9,500 errors annually had the potential to harm patients. Only about one-third of these serious errors are intercepted before medication administration.

Dispensing and stocking errors can have serious consequences. In a recent tragic report from Indiana, three babies died in the neonatal ICU. Two strengths of heparin were available in this hospital, and a pharmacy technician filled the automated dispensing cabinet on the neonatal unit with the adult strength of heparin. When the doses of heparin were obtained, the adult-strength medication was given to five babies, three of whom died. The vials looked very much alike. It is very easy to see how that could happen, and it is hard to blame the nurses on the units who actually administered those drugs.

A very recent study evaluated the impact of bar-coding drugs in the pharmacy and then checking them before they are sent to the patient care units. This study was done as a precursor to another study of the impact of bar coding in medication administration. Results showed that the dispensing error rate fell 31% after bar-code implementation, and the potential ADE rate (the “near miss” rate) fell 63% (Figure 2). This was a substantial reduction in the rate of potentially harmful errors.
Moreover, projections indicated that the implementation of bar coding avoided about 13,500 medication dispensing errors and more than 6,000 ADEs. Bar-coding technology had a differential impact on different types of errors: a 58% reduction in wrong medication errors, a 53% reduction in wrong dose/strength, and complete elimination of wrong dosage form errors.

Conclusion

Preventing Medication Errors lays out a blueprint for change in medication safety. The report makes clear that providers have many opportunities to improve. Technologies, such as computerized order entry, bar coding and smart pumps, and computerized ADE monitoring, will undoubtedly play a key role, and institutions should be thinking seriously about implementing a number of these. The report also emphasizes how essential a culture change, combined with well-designed technologies, will be to achieve the next level of safety called for in the IOM report.

References

14. ISMP. “Smart” infusion pumps join CPOE and bar coding as important ways to prevent medication errors. ISMP Medication Safety Alert! 2002 Feb 6.

Figure 2. Dispensing Errors and Potential Adverse Drug Events: Before and After Bar-code Technology Implementation. p<0.0001 (Chi-squared test).