



TECHNICAL REPORT

Electronic Prescribing Systems in Pediatrics: The Rationale and Functionality Requirements

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ABSTRACT

This technical report discusses electronic prescribing systems and their limitations and potential benefits, particularly to the pediatrician in the ambulatory setting. In the report we acknowledge the benefits of integrating these systems with electronic health records and practice-management systems and recommend that the adoption of electronic prescribing systems be done in the context of ultimately moving toward an electronic health record. This technical report supports the accompanying American Academy of Pediatrics policy-statement recommendations on the adoption of electronic prescribing systems by pediatricians.

INTRODUCTION

Electronic prescribing (e-prescribing) systems are computer applications designed for use by clinicians to generate paper or electronic medication prescriptions.¹ They offer the clinician and the patient the promise of safer prescribing and improved office efficiencies, 2 major drivers for the adoption of such systems. Many organizations, notably the Institute of Medicine (IOM), the Institute for Safe Medical Practice (ISMP), and the Leapfrog Group,² involved in efforts to improve medical quality and reduce medical errors, have endorsed e-prescribing systems as a major tool in reducing medical errors.³ The American Academy of Pediatrics has recognized that within the hospital, computerized physician order entry (CPOE) can prevent medication errors.⁴

One significant cause of medication errors has been the misinterpretation of physician handwriting. The National Hospital Ambulatory Medical Care Survey suggests that the prescription illegibility rate may be 1% to 2%.⁵ Illegible orders may account for 30% of errors.⁶

In their simplest implementation, e-prescribing systems provide printer-generated, easily readable prescriptions that are less likely to be misinterpreted or misread by a pharmacist. The most completely envisioned e-prescribing systems provide extensive decision support to the clinician and offer additional office efficiencies designed to streamline the prescribing and renewal process, facilitate insurance formulary adherence, and improve prescribing safety.⁷ This technical report will review the current state of e-prescribing to provide the clinician with an understanding of the subject and to better guide clinician decision-making in the adoption of this technology in the office setting.

CPOE is the component of the clinical information system that allows prescrib-

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The guidance in this report does not indicate an exclusive course of treatment or serve as a standard of medical care. Variations, taking into account individual circumstances, may be appropriate.

Key Words

electronic prescribing, clinical decision support, pediatrics, adverse drug event, computer assisted therapy

Abbreviations

e-prescribing—electronic prescribing
IOM—Institute of Medicine
ISMP—Institute for Safe Medical Practice
CPOE—computerized physician order entry
OR—odds ratio
ADE—adverse drug event
EHR—electronic health record
OTC—over-the-counter
ASP—application service provider
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ers to enter orders (for medications and/or clinical procedures) directly into a computer for electronic processing and transmission to appropriate departments and/or individuals for completion.⁸ The most obvious advantages of CPOE include the immediate transmission of orders without further transcription or delay to (usually) hospital departments, which eliminates transcription errors by nurses and speeds the health care–delivery process. Most research on CPOE has been performed in the inpatient setting. Analysis of research done on inpatient prescribing by the IOM resulted in the conclusion that 44 000 to 98 000 inpatient deaths could be attributed to avoidable medical errors, and many of these deaths could potentially be prevented by CPOE.⁹ In an analysis at 1 academic medical center, 64.4% of errors were rated as likely to be prevented with CPOE (including 43% of the potentially harmful errors).¹⁰

Less is known about the error rates and resulting morbidity and costs to the medical system that result from prescribing errors in the outpatient setting. In 1 study, the use of e-prescribing in the emergency department demonstrated a reduction in prescriptions that contained errors (odds ratio [OR]: 0.31) or required pharmacist clarification (OR: 0.19).¹¹ The Center for Information Technology Leadership projects that use of e-prescribing would prevent more than 3 million adverse drug events (ADEs) and prevent 190 000 hospitalizations yearly. Potential financial benefits from the universal adoption of e-prescribing include a savings of \$27 billion/year, including \$2 billion/year from the reduction in ADEs.¹² As noted previously, knowledge of the specific health, safety, and financial impact of drug errors and e-prescribing in the pediatric outpatient setting is considerably less well understood.

Despite these limitations, there is a groundswell for the adoption of e-prescribing by the medical community. Organizations such as the IOM, ISMP, and Leapfrog Group have strongly endorsed e-prescribing; the Centers for Medicare and Medicaid Services will require e-prescribing as part of its Medicare prescription drug program; and insurers are looking to these systems as a way to avoid costly medical errors and to “enforce” compliance with tiered formularies to drive down their pharmacy costs. Thus, a number of commercial insurers are now underwriting the upfront costs for physicians who are willing to adopt this new technology. Currently, 5% to 18% of physicians are using some type of e-prescribing system in their offices, with this number expected to grow rapidly over the next 3 to 5 years.

BENEFITS

E-prescribing has potential benefits for public health, the patient, the insurer/pharmacy benefits manager, and the physician. Specific benefits to each are noted below.

Benefits to public health include:

- reduction in medical errors and associated costs to society;
- reduction in drug diversion (forgeries);
- improved patient care and improved health outcomes; and
- improved efficiency and reduced costs associated with prescribing.

Benefits to patients include:

- reduced chance for medication misadventures; and
- improved patient satisfaction.

Benefits to pharmacists, pharmacy benefit managers, and insurers include:

- workflow efficiencies;
- improved compliance with formulary prescribing, with attendant reduction in drug costs; and
- reduction in costs attributable to preventable ADEs.

Benefits to the physician include:

- improved office efficiencies for medication renewals;
- incentive reimbursement for compliance with formulary programs; and
- improved record keeping and documentation.

CPOE AND E-PRESCRIBING SYSTEMS REDUCE MEDICAL ERRORS AND IMPROVE OUTCOMES

Hospital-Based Studies

Accurately determining the frequency of medication errors is limited by findings that medical errors are significantly underreported in the incident-reporting systems used by many hospitals, especially when errors did not reach the patient (near-miss events).¹³ Despite this limitation, however, 2.4% of hospitalized patients develop a clinically significant ADE during their hospitalization.¹⁴ Medication errors are one of the most common medical errors and the most frequent cause of adverse events, accounting for 19% to 20% of all adverse events.^{9,15,16} In pediatric patients, the most common type of medication error is a dosing error at the ordering stage.^{17–19}

Preventable ADEs (eg, ordering and administering an incorrect medication or dosage) are more common than nonpreventable ADEs (eg, a newly developed drug allergy). In 1995, Leape et al¹⁷ described poor dissemination of drug knowledge (29%) and inadequate availability of patient information (18%), such as the results of laboratory tests, as the most common causes of ADEs. An analysis of significant ADEs concluded that 52% of the cases were preventable; of these events, 50% could have been prevented by a pharmacist.²⁰

E-prescribing tools have been used successfully to reduce errors in the prescribing process. Use in the emergency department demonstrated a reduction in prescriptions that contained errors (OR: 0.31) or required pharmacist clarification (OR: 0.19).¹¹

Decision support provides knowledge, information, and data to the provider to optimize the selection and specification of medication for ordering. Such knowledge may be provided at the point of care through updated formularies for handheld devices and online guidelines and tools for specific domains such as infectious diseases.^{21,22} A computer-assisted antibiotic-management program was able to reduce ADEs and reduce total costs in 1 study²³ and reduce length of stay and antibiotic use in another.²⁴ E-prescribing tools have been used successfully to prevent the prescription of gender-specific drugs for patients of the opposite gender.¹⁰

Pediatric Studies

Children are at increased risk of certain specific types of ADEs. Pharmacologic factors, including age-based variability in absorption, metabolism, and excretion of drugs as compared with adults, pose special vulnerabilities to the adverse effects of overdosing (often by an order of magnitude). Physiologic factors, such as the nearly universal need for weight or body surface area considerations in dosing and recognition of the variability of organ development, also make the medication process for pediatric patients more prone to dosage errors than for adults.^{4,25}

Error rates for children seem to be inversely related to the weight of the patient, with infants in the NICU being most likely to experience medication errors and potential ADEs.^{26,27} A study of errors for preterm neonates before discharge demonstrated a linear increase in medical error rates that was inversely related to birth weight, although the overall rate of errors was lower in comparison with children and adults.²⁸ Medical errors in pediatric patients are more likely to be caused by calculation or dose errors than in adults. Medications in adults that require weight-based calculation (the norm for pediatric patients) were found to be more error prone.^{29,30}

Process factors, including the need for individualized dilution of stock medications and fluids (because of weight and body surface area considerations), place children at increased risk of medication errors in comparison with adults. Location-specific factors, such as the fast pace and high complexity in ICUs, are associated with a sevenfold risk of medication errors.³¹

Medication errors may occur at any step in the process, from ordering (56%) to transcription (6%), dispensing (4%), and administration (34%).³²⁻³⁴ Orders by prescribers are the most error-prone steps in the medication process, with the wrong dosage being the most common type of error.³⁵⁻³⁷ These errors may or may not be caught by subsequent checks, such as during dispens-

ing and administration.³⁸ In pediatric inpatients, almost three quarters of all medication errors were discovered in the ordering stage.²⁷ In academic pediatric critical care settings, prescribing error rates of 11% to 30% were observed, compared with 6% of prescription errors in an internal medicine setting.^{10,39,40}

The evidence for error reduction in pediatric patients using computerized systems is not yet robust. A recent Cochrane review⁴¹ concluded that limited data from randomized trials exist on which to assess the effects of clinical decision-support systems in neonatal care. However, some evidence that highlights the benefits of CPOE in the neonatal population is emerging. Cordero et al⁴² reported that implementation of CPOE resulted in a significant reduction in medication turnaround times and medication errors for selected drugs (gentimycin) and a decrease in ancillary service (radiology) response time. CPOE eliminates illegibility. Vanderbilt University's WizOrder system reduced the rate of errors caused by illegible pediatric intensive care orders from 1 error per 100 orders to zero.³⁹ CPOE with calculators and point-of-care decision support has also been used successfully to drastically reduce provider errors in the ordering of total parenteral nutrition⁴³ and continuous infusions.⁴⁴ An ambulatory study from Singapore showed that automated calculation reduced pediatric prescribing errors from 28.2% to 12.6%.⁴⁵ CPOE has also been shown to reduce errors in the ordering of chemotherapy agents in pediatric patients.⁴⁶

Ambulatory Care Studies

ADEs are common in ambulatory care, and many are preventable or ameliorable.³⁴ E-prescribing tools in outpatient settings have been used successfully to lower prescription costs through electronic, evidence-based decision support during the prescribing process.⁴⁷ Computerized prescription systems have been shown in randomized trials to improve the quality of anticoagulation.⁴⁸

LIMITATIONS OF CPOE AND E-PRESCRIBING IN REDUCING ERRORS

Computerized ordering and prescription tools have been advertised as means to reduce the frequency of ADEs.⁴⁹ However, evidence exists that computerized systems cannot prevent all errors or ADEs and may, in some situations, be responsible for new types of errors.^{50,51} A recent study of a 110-bed computerized Veterans Administration hospital found 70 ADEs per 100 patient-days (significantly higher than previously reported).¹⁴ The authors suggested that the legible and accessible electronic records may have facilitated the increased identification of ADEs. Of note in the Veterans Administration study is the finding that errors in ordering (74%) accounted for a larger percentage of errors than previously reported (56%).⁵¹ At the same time, errors

during transcription and administration were reduced. The authors speculated that these findings were a direct result of the system design—a computerized system that eliminates need for transcription and ensures legibility but lacks decision support for drug selection and dosing—and will “redistribute” error frequencies. In other words, unless an electronic system is designed to prevent errors at the ordering stage, it will not prevent these errors; on the contrary, it will increase the speed at which these errors can be committed and executed. Another recent study from the University of Pennsylvania that evaluated an older CPOE system with very limited decision support received significant media attention when the authors concluded that a leading CPOE system often facilitated medication-error risks.⁵⁰ Although there was no comparison between manual ordering and CPOE, the authors emphasized that electronic systems will do just what they are designed to do. If they are not designed to provide decision support, they will not do so. In contrast, a study of the WizOrder CPOE system at Vanderbilt University demonstrated that a CPOE system that includes sophisticated decision support at the point of order entry may reduce medication-prescribing errors by 99.4% and rule violations (deviations from ordering policy) by 97.9%.³⁹ A recent study in a PICU showed that implementation of a CPOE system, even in the early months after implementation, was not associated with an increase in mortality.⁵²

In addition to incomplete design, computerized prescription-writing tools are limited to the content of the program. For example, they may have a limited drug inventory or lack dose-range information and may, especially when used on handheld devices, pose usability problems.⁵³ Fernando et al,⁵⁴ who used simulated test cases, found that computing systems currently in use in approximately three quarters of general practices in the United Kingdom have clinically important safety deficiencies.

The Rand Electronic Prescribing Expert Advisory Panel has provided 60 capability recommendations for ambulatory prescribing systems.¹ However, a recent study of 10 commercially available e-prescribing systems demonstrated that only 50% (range: 26%–64%) of these recommendations were implemented.⁵⁵ It must be recognized that electronic systems are only as good as they are designed and implemented. A system that strives to provide legibility and accessibility only will improve the error rate in transcription and administration processes but not in ordering processes. For CPOE and e-prescribing systems to reduce provider ordering errors, they must be integrated with sophisticated clinical decision-support capabilities.³⁹

E-PRESCRIBING SYSTEMS

An e-prescribing system, at its simplest, is a computer application that allows physicians to print out prescrip-

tions (a word processor would fulfill this definition). The advanced vision of an e-prescribing system, however, is that of an application that facilitates the rapid and efficient generation of prescriptions (including electronic renewals); includes a knowledge base with drug information relevant to the prescribing process; performs all necessary calculations automatically and accurately; checks for prescription completeness, drug contraindications, drug interactions, allergies, and medical conditions that affect prescribing; verifies appropriateness of dose on the basis of patient age, weight, gender, and medical conditions (eg, renal insufficiency); checks insurance formulary preferences; and then transmits the prescription electronically to the pharmacy. An ideal closed-loop system would also receive data back from the pharmacy to confirm that the patient has filled the prescription.

Although generating printed prescriptions would be expected to reduce medical errors related to handwriting, it is the integrated clinical decision support, automatic calculations, and electronic transmittal functions that are likely to have the greatest effect on physician prescribing habits and to improve the safety and efficiency of the prescribing process. Merely printing out prescriptions can be done on a word processor; a fully functional e-prescribing application requires significant domain knowledge often contained in database tables and is most effective when integrated (bidirectional data transfer) with office practice-management and/or electronic health record (EHR) systems. Higher levels of systems are associated with higher startup costs and complexity and are generally associated with higher benefits. These levels of e-prescribing have been described.

Electronic Drug Reference Only; No Prescription-Writing Capability

This functionality is supplied by commercially available software programs, many of which are designed for mobile personal digital assistants, that allow access to drug dosages, contraindications, adverse effects, and drug interactions. It is important that reference data be kept current and updated at least monthly.

Stand-Alone Prescription Writer With No Medication History or Supporting Data

In addition to providing electronic drug references, a stand-alone writer provides computerized printing of prescriptions that are then given to the patient or manually faxed to the patient’s pharmacy.

Reference Data and Prescription Writer With the Addition of Basic Supporting Data Such as Allergies, Demographics, Past Prescriptions and Formulary Information, Which Can Be Used to Generate Alerts

This functionality allows the application to incorporate clinical decision support (including drug-allergy, drug-

drug, and dose-range checking; renal function adjustments; and possibly preferred insurer formulary information) but requires the input of information (eg, demographics, allergy history, other concurrent medications, renal function/creatinine), often manually, depending on interfaces to practice-management systems, laboratory systems, EHRs, and insurer formulary databases.

Medication Management: Long-term Tracking and Monitoring of Each Patient's Active Medications

This level contains the previous functionality and maintains a database of the patient's previous prescriptions and prescription renewals. These applications typically monitor for drug-drug interactions automatically. These systems should also allow for the manual entry of other medications the patient is taking. Less commonly available, but useful, is the ability to enter alternative and nonprescription medications. Some vendors offer the ability to check for drug interactions with alternative medications.

Unidirectional Connectivity From Practices to Pharmacies, Payers, Pharmacy Benefit Managers, or Clearinghouses

This type of system typically provides the previous functions and allows for the electronic transmittal of prescriptions to pharmacies and often includes subscriptions to electronic versions of insurance formularies to identify preferred and tiered drugs and alert for noncovered medications. This requires that patient insurance information be entered into the e-prescribing system or transferred from practice-management systems.

Integration With a More Complete EHR

Systems integrated with an EHR allow for a wider range of clinical decision support without the need to manually reenter data into the e-prescribing system. They also automatically update the patient's current medication list within the EHR.

Bidirectional Connectivity Between Physicians, Pharmacies, Payers, Pharmacy-Benefit-Management Programs, or Clearinghouses

This functionality is not generally available in systems today but is in the planning stages. It would allow for feedback of prescription information from the pharmacy to the clinician, such as confirming that the prescription has been received, has been given to the patient, or is overdue for refilling, thus enabling compliance monitoring by the physician and improved medical management.

Bidirectional functionality could allow physicians to receive up-to-date information from other physicians' prescribing systems or from the pharmacy on their patient's prescriptions, such as information on prescriptions prescribed by another physician or in another care

setting. Up-to-date medication lists are essential for accurate drug-interaction checking.

BARRIERS AND POTENTIAL SOLUTIONS TO E-PRESCRIBING ADOPTION

Despite the opportunities potentially available with the use of e-prescribing systems, a number of potential barriers have slowed their adoption. Among others, these barriers include the following.

Failure to Recognize Current System Deficiencies

Often, physicians do not perceive that they make prescription errors or have illegible handwriting. They do not perceive themselves as part of the drug-error problem and are often reluctant to change their practices.⁵⁶

Technology Barriers (Equipment Setup and Maintenance) in the Office Setting

The lack of access to a broadband Internet connection especially affects smaller and more rural practices. Those practices may also suffer from lack of access to the technological support they need.

Implementation, Training, and Maintenance Cost

Establishing e-prescribing in the office is not a 1-time expense. Licensing and maintenance-agreement costs are ongoing and are generally not offset by a reduction in other office expenses. E-prescribing may not be more time-efficient than handwriting prescriptions and could affect office productivity, particularly in the initial implementation phase. Additional manual data-entry requirements may also reduce efficiency. Potential office cost benefits may result from improvements in the medication-renewal process, reduction in manual chart pulls, and compliance with insurer incentive programs for using generic or preferred drugs. However, even these efficiencies may not always allow for a reduction of office staff, which would equate to decreased office salary expense.

Beneficiary-Payer Discrepancy (Misaligned Incentives)

Although providers must carry the bulk of the investment for e-prescribing systems, benefits from automation are more likely to accrue primarily to others such as insurers, pharmacists, and patients. Patients appreciate the potential of having prescriptions ready to be picked up without a wait. Without incentives to physicians to invest in e-prescribing systems, the adoption of this technology by physicians is likely to be slow.¹²

Interface/Integration Costs

It is likely that physicians in the future will want to implement a complete EHR system in their offices. Transferring data from the e-prescribing system or integrating the e-prescribing system with an EHR system can be difficult and expensive. Physicians expecting to move

to an EHR system in the near-to-medium future will need to build in a transition strategy to avoid duplicate data-entry costs.

Existing Legacy Systems

Although most pharmacies can accept facsimile transmissions, many still do not have the ability to electronically accept transmitted prescriptions into their electronic pharmacy systems and, thus, miss out on potential benefits. Even where pharmacies can accept the electronic transmissions or facsimiles, pharmacy workflow may be such that the drug is not dispensed before the patient arrives to pick up the medication.

Legal and Regulatory Barriers

In regard to e-prescribing, nonuniform state regulations and lack of federal standardization (preempting state regulations) place an additional burden. In particular, regulations on controlled substances that mandate triplicate prescriptions and special forms may significantly limit the use of e-prescribing. Pediatricians commonly prescribe schedule II controlled substances (eg, stimulants for attention-deficit/hyperactivity disorder) and might, therefore, not be able to fully benefit from e-prescribing. The Drug Enforcement Agency currently allows e-prescribing of controlled drugs in category III to VI and is considering issuing digital certificates and using public-key infrastructure encryption to allow for digital prescription for category II drugs.⁵⁷ Until state and federal legislatures generate a uniform regulatory approach, e-prescribing systems are required to fulfill all mandates or to be tailored for use in specific states.

Negative Past User Experiences

Poorly designed systems have been available for several years and may have given the market a bad reputation. Current systems are evolving to be more user friendly, intuitive, and customizable. Nonetheless, any potential user of an e-prescribing system should test a system that is in actual use before investing the significant resources required. Testing should include some of the more complex prescriptions used in practice, such as prednisone tapers, drugs that require additional information or diagnosis to be included on the prescription, drugs with as-needed indications, and over-the-counter (OTC) drugs (covered by some insurers with prescription). Physicians must be aware of the fluidity of the vendor market and must appreciate the risk involved in the bankruptcy, sale, or merger of their e-prescribing system vendor and the possible subsequent discontinuation of software maintenance and technical support for their system.

Lack of Standards

Several transmission standards for prescriptions exist; however, a move toward consolidation of standards has

been underway, and the recent Centers for Medicare and Medicaid Services move to establish electronic standards under the Medicare Part D prescription drug plan will help to establish a de facto standard.⁵⁸ However, these rules, regulations, and standards only apply to prescription drugs. E-prescribing systems may not be set up to handle prescribing or provide decision support for OTC and alternative medications.

OPTIONS AND FUNCTIONAL REQUIREMENTS

There are many ways to implement e-prescribing systems; solutions that work for one practice may not work for another. Careful consideration of the risks and benefits of implementation alternatives is necessary. It is critical that physicians considering the use of e-prescribing be aware of the risks including costs (purchase, training, workload, and maintenance) as well as legal and regulatory requirements in their state.

All systems that are capable of electronically transmitting prescriptions share certain characteristics such as a need for connectivity. Most will require dedicated telephone lines or broadband Internet connectivity, a potential problem in more remote areas. All of them will require a computer, modem to connect to the telephone (usually dedicated digital subscription line) or Internet (via digital subscription line or cable), and likely a router. The need for connectivity may introduce a single point of failure in which a malfunction may render the whole system inoperable, particularly for those applications that run as an application service-provider (ASP) system.

If more than 1 computer or device in the office is to be used for prescribing, a computer network or a way to synchronize information will be necessary. The input equipment can be a computer (desktop, laptop, tablet computer), wireless handheld device, or personal digital assistant. The network can be wired, wireless, or a combination of both. A wireless router and perhaps several wireless antennas will be required for wireless networks. When local printing of prescriptions is planned, printing may be centralized within the office, or multiple printers may be necessary, possibly convenient to each examination room. If integrated electronic facsimile transmission is not part of the e-prescribing system, a fax machine for manual transmission may be required. Technical help is usually required to wire and set up networks.

Systems can be administered from off-site centralized locations through an ASP, where everything is “done for you” to manage the system, or maintained on-site in the office. ASP systems use secure connections to allow office access devices to be logged into the remote system. With the ASP model, patient data are typically stored off-site, but in either case regular data backups need to be ensured.

Computer interfaces to transfer data from other office

systems (eg, practice management or scheduling) can initially be expensive but may save providers time by eliminating the need to enter demographic data and by keeping data current and synchronized across multiple systems with single data entry. There are usually additional costs associated with purchasing and integrating various databases, including insurance company drug formularies, prescribing-information updates, decision-support data, and pharmacy lists with up-to-date fax numbers.

A number of insurers have been paying the implementation costs for selected e-prescribing systems, at least for their high-volume prescribers. Insurance companies expect to realize benefit from providing e-prescribing systems to providers by steering physicians to the selection of specific preferred drugs and the reduction in ADEs to insured clients. Some medical societies have negotiated “discounted” deals with preferred e-prescribing providers. It is estimated that the direct cost of implementing a stand-alone system can be under \$2000 per physician and, in some cases, considerably less. However, the cost of implementing an integrated EHR with an e-prescribing component is considerably higher. Providers will need to determine if an integrated EHR solution, although more expensive and difficult to implement, will have other offsetting benefits that would justify the additional work and expense.

Physicians must be aware that the market for these applications is somewhat “fluid” as vendors come, go, and merge with others. Choosing a product from a well-established, financially stable vendor, although no guarantee of sustainability, will help to ensure longer-term product support. Thus, it is important that an “exit strategy” be in place, including provision for recovery of the data contained in the system (in a standard nonproprietary database format). Ongoing costs are for equipment depreciation and replacement, renting telephone or Internet access, licensing and maintenance-agreement costs, and staff training and can vary considerably.

An expert consensus panel recently published recommendations for comparing e-prescribing systems.¹ They categorized the functionality to be assessed into the categories summarized below. They noted that no current system met their recommended criteria fully.

Patient Identification

Patient name, gender, and date of birth or age must be visible throughout the ordering process. These data should be imported from other systems when available, or the system should allow for manual entry when not imported. Duplicate records created under separate identities for one individual should be able to be reconciled and merged. The ability to perform patient searches using combinations of date of birth, gender, and partial name helps to positively locate and identify patients.

Access to Patient Historical Data

The system and clinicians should have access to external sources of data (hospitals, pharmacies, laboratories, EHRs) and be able to review all patient prescriptions, not just those written by the current provider, as well as OTC and alternative medications taken by the patient. The ability to manually enter additional patient medications is required. Current and past medication-prescription details should be viewable by class, with start and stop dates. When a medication is discontinued or changed, a notification should be sent to the original prescriber. When a diagnosis is entered, a list of medications by diagnosis should be viewable.

Medication Selection

When the e-prescribing system is presented with a patient diagnosis, a customizable selection of appropriate medications should be presented to the user. Prepopulated lists or dynamically maintained lists of common medications based on prescribing frequency can speed medication ordering. Medication options should not be influenced by vendor or insurer promotional considerations.

When the system displays a preferred drug, the rationale for that preference should be immediately viewable, and contraindicated medications (based on allergy or drug interactions) should not be viewable as a preferred medication choice. Prescribing by medication name should override restricted-medication menus. The system should provide formulary status and cost to the patient for medication options on the basis of insurance and any benefit or prescribing caps. Clinical summary data useful to the selection process should be easily accessible.

The user should be able to easily select the drug form and available strengths for each medication. Dosing recommendations based on calculations of body size (weight or body surface area) and age, when appropriate, should be available. When appropriate, adjustments calculated and based on renal and liver function should be made. The ability to default to generic drug name on prescriptions should be available (unless specifically overridden) to aid in insurance prescribing compliance programs and reduced costs to patients.

Alerts and Other Messages to Prescribers

Dose-range checks based on dose, dose per weight, daily dose, daily dose per weight, and lifetime dose-checking alerts should be available. Prescribers should be alerted when there is a contraindication or precaution based on allergy, drug interaction, medical condition, or laboratory results. The system should send a reminder when a medication is indicated in a particular instance (immunization due or medication based on diagnosis, laboratory results, and peer-reviewed recommendations). Messages should provide a clear rationale for any rec-

ommendations. Messages not based on patient safety concerns should be suppressible to avoid “alert fatigue.” A user should be able to prioritize safety alerts and set a threshold that allows only alerts of a certain level/priority to result in a message to a provider while other alerts are suppressed. Providers should be able to override alerts with reasonable justification, and the system should track all changes and their justification. Prescribers should be able to flag or correct (update) incorrect information.

Patient Education

Patient medication-information sheets, written at an appropriate level for patients and their parents, and patient medication lists should be printable. Information sheets should be editable or customizable (and then saved for reuse) for pediatric indications (eg, β_2 blockers used for migraine control, not heart disease; digoxin for arrhythmia control, not congestive heart failure). Patient education materials should be able to be edited or personalized and be available in other languages in addition to English.

Data Transmission and Storage

Prescriptions should be able to be transmitted to the patient’s pharmacy of choice. Transmission should conform to current Health Level 7 (HL7) and National Council for Prescription Drug Programs standards. Physicians should receive transmission and dispensing receipts and should be notified of any transmission failures.

When prescriptions are printed locally and given to the patient, prescription abbreviations should be avoided, and the prescriptions should be consistent with best-practice recommendations (eg, Joint Commission on Accreditation of Healthcare Organizations or ISMP).^{59,60}

Monitoring and Renewals

The prescriber should be notified electronically when a prescription or refill is not dispensed within a provider-specified time period. Ideally, the system should alert the clinician to place orders for manufacturer-recommended laboratory monitoring and alert the physician when laboratory results require action. Prescriptions and renewals entered should be clearly attributable to the person who enters the order.

Many e-prescribing systems have a messaging ability integrated into the system so that nurses and clerical staff can access the system and forward renewal requests that come in directly from patients. Office processes and staff training needs require attention.

Transparency and Accountability

The system should clearly display any sponsorships or relationships that could represent conflicts of interest

and any sources and methods used to develop clinical decision-support rules and messages.

Prescriber-Level Feedback

Prescribers should be able to review profiles of their own prescribing patterns and history of overriding alerts.

Security and Confidentiality

Systems must be compliant with the Health Insurance Portability and Accountability Act (HIPAA). Access to protected health information should be auditable. Each user should have a unique sign-on and password and role-based access privileges. The system should support data integrity checking of stored and transmitted data. Provisions for the routine backup of data and secure storage must be considered. Firewalls may be needed to protect systems, and antivirus software must be current if the network is not dedicated to the e-prescribing application. Access-management processes must be in place (eg, to revoke access when an employee is terminated).

CONCLUSIONS

Ultimately, the issue for consideration is “not if, but when.” A uniform system for providing incentives and removing barriers to the adoption of e-prescribing systems by physicians who wish to use these systems will likely be needed to accelerate the migration to e-prescribing. The expenditure of time and money to implement a well-designed e-prescribing system has the potential, in the long run, to benefit society, the patient, the insurer, and the physician.

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