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Electronic Prescribing in Pediatrics: Toward Safer and More Effective Medication Management

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TECHNICAL REPORT

Electronic Prescribing in Pediatrics: Toward Safer and More Effective Medication Management

abstract

FREE

This technical report discusses recent advances in electronic prescribing (e-prescribing) systems, including the evidence base supporting their limitations and potential benefits. Specifically, this report acknowledges that there are limited but positive pediatric data supporting the role of e-prescribing in mitigating medication errors, improving communication with dispensing pharmacists, and improving medication adherence. On the basis of these data and on the basis of federal statutes that provide incentives for the use of e-prescribing systems, the American Academy of Pediatrics recommends the adoption of e-prescribing systems with pediatric functionality. This report supports the accompanying policy statement from the American Academy of Pediatrics recommending the adoption of e-prescribing by pediatric health care providers. *Pediatrics* 2013;131:e1350–e1356

The US health care system has the distinction of being the world's most expensive delivery system while also having among the lowest levels of quality, as judged by many metrics, including infant mortality, life expectancy, and potential years of life lost.[1,2] More specifically, despite US leadership in establishing many standards of care that correlate with improved quality, the US health care system is able to deliver, at best, 60% of the recommended care in most practices.[3,4] Reasons for this inefficiency include the voluminous information resources to consult and the experts' parallel processing and modeling skills (including integrating considerations of the patient's other illnesses, lifestyle, and genome) required to make an optimal decision.[5] Other challenges include the health care system's existing methods of payment, which lead to fragmented care.[6] Difficult-to-resolve health disparities also occur when there are suboptimal interactions between a person's preferences, the regulatory/operational health care system, and internalized biases, stereotypes, or knowledge deficits. All of these challenges to information management affect the delivery of care.[7] For these reasons, health information technology (HIT) has become recognized as a set of tools that complement the provision of care.[8] Electronic prescribing (e-prescribing) is widely recognized as a component of the prescribing process that facilitates handoffs, improves clinical decision-making, and may improve medication adherence. E-prescribing was defined in 2008 by the Centers for Medicare and Medicaid Services as a system providing prescribers with

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KEY WORDS
health information technology, electronic prescribing, quality improvement, pediatrics, medication, prescription

ABBREVIATIONS
CBO—Congressional Budget Office
EHR—electronic health record
HIT—health information technology
HITECH—Health Information Technology for Economic and Clinical Health
MIPPA—Medicare Improvements for Patients and Providers Act

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the ability to generate and "electronically send an accurate, error-free and understandable prescription directly to a pharmacy from the point-of-care."

RATIONALE FOR ADOPTING E-PRESCRIBING

Adoption of e-prescribing has been strongly endorsed by a variety of professional societies and federal agencies for more than a decade.[9-13] The reason for almost unanimous support for e-prescribing tools is the mounting evidence in adult populations that e-prescribing can improve prescribing quality and provide better pharmacovigilance. Monitoring pharmaceuticals requires collecting, observing, researching, assessing, and evaluating data and derivative information related to safe, effective, and consistent medication use. Pharmacy data management successes reveal a path for transforming medication communication throughout the health care system. The Institute of Medicine summarized this literature in its publication *Preventing Medication Errors*[14] and recommended national mandates for this technology. There is less literature specific to pediatric populations; however, the literature that is specific to this population has been encouraging.

Quality Challenges for E-Prescribing in Pediatrics

By far, the strongest rationale for adopting e-prescribing recognizes the inherent challenges with pediatric prescribing, which are responsible for an error rate in children of between 5% and 27% in a recent systematic review.[15] Physiologic factors, such as the nearly universal need for weight or body surface area considerations in dosing, make medication ordering more prone to errors in children than in adults.[14,16,17] In addition to these physiologic factors, the therapeutic window for many drugs is smaller for children than adults. Pharmacologic factors, including age-based variability in absorption, metabolism, and excretion of drugs in children as compared with adults, as well as the age-specific contraindications of certain medications, pose special vulnerabilities to the adverse effects of overdosing. The conversion of doses from ingredient amounts to volumes for liquids labeled for home use is also problematic.[18-20] Prescribing errors are most prevalent with antibiotic agents but may occur even in medications that do not require weight-based dosing or ingredient-to-volume conversion.[21] Medication errors in children may lead to more severe complications because of the inability of children to communicate some adverse effects.

Decreased Preventable Adverse Drug Events

Adverse drug events are defined as injuries "resulting from medical intervention related to a drug" and are the leading cause of iatrogenic harm to patients.[22] The Institute of Medicine conservatively estimated that each year, more than 1.5 million preventable adverse drug events occur in the United States.[14] In an ambulatory study in adults, 25% of patients experienced 1 or more adverse drug events (27 events per 100 patients).[23] Estimates in 1995 placed the cost of drug related morbidity and mortality between $20 billion and $130 billion, with most of the cost stemming from drug-related hospital admissions.[24]

The rate of adverse drug events attributable to ambulatory drug administration has been estimated at 3% to 4% in 1 study.[25] This rate is highest in children taking multiple prescription medications.[26] Pediatric patients, although less likely to suffer harm from an adverse event, are susceptible to more types of adverse events, but the quality of the evidence is variable.[27,28] Studies evaluating e-prescribing systems reveal consistent reductions in potential adverse drug events in systems that organize and coherently report medication summaries.[29-31]

Reducing Dosing Errors

Dosing errors represent the most common medication error in pediatrics.[32] Although seemingly easy to catch, dosing error-checking is complicated by the fact that children's weights vary from as little as 500 g for micro premature infants to well over 100 kg for some obese adolescents, differing by a factor of more than 200. To illustrate the challenge, 2 patients (1 weighing 2 kg and the other 100 kg) discharged with a prescription for 5 mg/kg per day of ranitidine could receive a dose of between 10 mg and 300 mg a day and still not catch the attention of a pharmacist, because all doses between these amounts are reasonable for children, depending on their weight.

E-prescribing systems are able to present standardized dosing formulae, to use the patient's weight to calculate a dose, to convert that dose to a volume for liquids, and to present that dose in a format that is least likely to be confusing to the prescriber, pharmacist, nurse, or parent. Truly sophisticated prescribing systems use individual dose limits and total daily dose limits, compared with weight- or body surface area-based normal values.[33] Some particularly sophisticated systems write out the final dose (ie, "ten [10]") to further improve clarity and to reduce the risk of prescription tampering.[34] Finally, a recent article demonstrated the power of annotating electronic prescriptions with the actual calculation leading up to the dose.[35]

Improved Communication

After dosing errors, missing information and illegible prescriptions cause

the majority of prescribing errors in children[36] and significantly impede the ability for these errors to be caught by pharmacists or other health care providers. Illegible handwriting may be at fault for at least 20% of all errors.[26,37] Groups such as the Pediatric Pharmacy Advocacy Group, the Institute for Safe Medication Practices, and the American Society of Health System Pharmacists[38] have espoused requirements for safe pediatric prescribing, recognizing that these prescriptions should include information about the child's age, weight, and indication for therapy and should adhere to a format (eg, no trailing zero) that minimizes miscommunication. The Institute for Safe Medication Practices, the American Academy of Pediatrics, and other groups support the labeling of all prescriptions for liquid medication with volume in milliliters (mL).[39-41]

Parental health and English literacy has been shown to play an important role in the correct medication administration in children.[42,43] E-prescribing systems may provide administration instructions that are appropriate for the parents' or child's health literacy and can be provided in the patient's or her family's primary language.

Software can default or force entry of specific information. For example, a date may be automatically populated, a weight may be pulled from an existing electronic health record (EHR), and a user may be prevented from completing the prescription until essential information has been completed. Pharmacists view the net effect of e-prescribing as positive in the areas of patient safety, effectiveness of care, and efficiency of care.[44,45] In pediatrics, e-prescribing can improve communication through both improving clarity of prescriptions and providing standardized information about indications for therapy, rationales for overriding allergy alerts, and the weight-based calculations leading to a specific dose.[35] For all patients, e-prescribing systems can improve communication about provider willingness to allow generic substitution,[46-48] which, by avoiding higher copayments, can improve medication adherence.[49]

A study on prescriptions[35] demonstrated the value of including body weight and the process associated with calculating a dose. In this study, pharmacies stated that prescribing safety was improved by "showing your work" related to the cognitive processes associated with prescribing and found it especially beneficial in pediatric prescribing.

Avoiding Adverse Effects

Medication adverse effects may be related to interactions between a medication and the host (allergies or unintended effects) or may be related to other patient medications, dietary choices, or other diagnoses. These unintended consequences may be life-threatening or, more commonly, may lead to poor therapeutic adherence by children and families. Often, these consequences can be ameliorated by choosing an equally efficacious alternative therapy at the time of the initial prescription or after onset of the unintended effect. E-prescribing systems can display results of past therapy and help avoid prescribing medications that may not be tolerated. Systems that are more sophisticated warn about potential unintended effects, thereby decreasing the burden on the family and potentially having a beneficial effect on the economics of health care.[50,51]

Improving Efficiency

The process of prescribing and ensuring adherence is 1 of the most time consuming in practice settings. Both new and refilled prescriptions require attention to the 5 rights: making sure the right patient receives the right medication in the right dose, using the right route, and at the right time. E-prescribing is able to help with many of these issues by providing early warnings for duplicate therapies, contraindications for use (such as in pregnancy or for lactating mothers), and other prescribing risks mentioned previously.

As a component of an efficient practice, e-prescribing may decrease delays in renewing chronic medications or in flagging renewals as inappropriate. In pediatrics, there is an additional challenge of modifying a dose for some medication refills as the child grows, which can be facilitated by information technology. Perhaps the most pervasive way that e-prescribing can boost practice efficiency is by recognizing the distributed nature of work in the ambulatory setting. For example, a well-designed e-prescribing system might allow a refill or new prescription to be drafted by 1 provider or designee and completed by an authorized prescriber either in the office or any location by using Web-enabled information technology.[34]

E-PRESCRIBING SYSTEM FUNCTIONAL REQUIREMENTS

The theoretical benefits of e-prescribing systems in pediatrics can only be achieved by systems with appropriate functionality and may be hampered by poorly developed systems[52] or implementation strategies.[49] At present, many e-prescribing systems fall short of providing expert recommended functional characteristics.[53] These features broadly cover patient identification and data access, current medication/medication history availability, medication selection, alerts and reminders, medication information, data transmission/storage, monitoring and renewals, prescribing practice feedback, and system security/confidentiality.

The use of e-prescribing systems in children will require overcoming some unique challenges inherent in pediatrics. Paramount among these challenges is the question about the relevance and sensitivity of drug interaction or adverse-effect alerts.[54,55] The existing insensitivity results in many false-positive alerts and subsequently in override rates ranging from 89% to 91%.[25,56-58] Although few studies have been published that assess this phenomenon in children, children tend to be on fewer chronic medications and, because of generally good renal and hepatic function, may be less at risk for severe adverse reactions,[59] thereby magnifying this concern in pediatrics.

Age- and indication-specific weight-based dosing requirements, coupled with the fact that home administration may be associated with a high potential for errors,[21] place additional requirements on the pediatric e-prescribing system (dose rounding, minimum/maximum dosing checks, etc) that may not be as important for adult prescribing. E-prescribing systems need to modify both dosing guidelines and dose-screening parameters to support pediatric dosing for every indication that warrants modified dosing regimens. Furthermore, they need to support the desire to provide easily administered home doses (in mL for liquids) and, when necessary, extemporaneously compounded dosage forms. In short, these systems will need to evolve to be an ideal platform for safe and effective pediatric medication prescribing, although they already confer numerous advantages over the paper-based alternative. The features listed in Table 1, derived in part from previous work by the American Academy of Pediatrics,[16] will help address these challenges to safe and effective pediatric e-prescribing.

TABLE 1 Pediatric Requirements for Safe and Effective Electronic Prescribing

Category	Pediatric Requirements
Patient information	Date of birth or age in units more specific than years
	Weight in kg
	Height in cm
	Any history of intolerable adverse effects or allergy to medications
Medication information	Indication-based dosing and individual and daily dose alerts, using mg/kg per day or mg/m^2 per day formula, unless inappropriate
	Weight-based dosing calculations
	All available formulations, including liquid formulations that may be specific brands
	Common formulations requiring extemporaneous compounding or combinations of active ingredients
Cognitive support	Dose range checking (minimum and maximum amount per dose, amount per day based on weight, surface area, and total dose)
	Automatic strength to volume conversions for liquid medications
	Adverse-effect warnings specific to pediatric populations
	Alternative therapies based on ameliorable adverse effects
	Tall-man lettering to reduce medication selection errors
	Medication-specific indications to reduce ordering of sound-alike drugs
Pharmacy information	Pharmacies that will create extemporaneous compounds
Data transmission	Use of messaging standards for data transmission to pharmacies that include the patient's weight and notes pertaining to weight-based calculations
	Transmission of strength, concentration, and dose volume labeled in metric units for liquid medications

FEDERAL INITIATIVES TO IMPROVE E-PRESCRIBING ADOPTION

The past decade has been an active one for the national medication prescribing landscape. In particular, 2 major statutes specifically address the goal of 100% e-prescribing adoption through both time-dependent incentives and penalties. Each of these statutes will be described below.

Medicare Improvements for Patients and Providers Act

The Medicare Improvements for Patients and Providers Act (MIPPA) became law on July 15, 2008 (Pub L No. 110-275). MIPPA was designed to avert a statutory Medicare reduction in payments for physicians and implement other changes. In addition to its effect on physician fees, MIPPA addressed the chasm between literature describing improved quality of care related to e-prescribing and the current state of poor adoption (especially among health care providers caring for older and sicker populations). It addressed this chasm by incentivizing the adoption of e-prescribing by authorized prescribers. MIPPA created new financial incentives to encourage physicians who provide services to Medicare patients to adopt technology that will allow them to order prescriptions electronically. Use of this technology is meant to reduce medical errors and help physicians consider cost issues as they make prescribing decisions. Under MIPPA, beginning in 2009, physicians received a 2% increase in payments, phasing down to 0.5% in 2013. However, in 2014 and afterward, physicians who have not implemented the technology will lose 2% of their payments. The incentives and penalties under MIPPA may have less of an effect on pediatric patients, because not all pediatricians see a sufficient number of Medicare-eligible patients.

The Health Information Technology for Economic and Clinical Health Act

The Health Information Technology for Economic and Clinical Health (HITECH) Act was incorporated as part of the American Recovery and Reinvestment Act of 2009 (H.R. 1), the economic stimulus bill signed into law on February 17, 2009 (Pub L No. 111-5). The HITECH Act is intended to promote the widespread adoption of HIT to support the electronic sharing of clinical data among hospitals, physicians, and other health care stakeholders. According to a 2009 report by Surescripts (http://www.surescripts.com/downloads/npr/national-progress-report.pdf), the number of prescribers sending prescriptions electronically more than doubled from 2008 to the end of 2009 to 156 000, which corresponds to only 25% of all office-based prescribers. The same report stated that 85% of community pharmacies, as well as the 6 largest mail-order pharmacies, were able to receive electronic prescriptions. Therefore, the infrastructure for e-prescribing is nearly ready, but prescribers have not yet fully adopted this technology. The HITECH Act builds on existing federal efforts to encourage e-prescribing/HIT adoption and use. The Congressional Budget Office (CBO) estimates that Medicare and Medicaid spending under the HITECH Act will total $32.7 billion over the 2009–2019 period. CBO hypothesizes, however, that widespread HIT adoption will reduce total spending on health care. Through 2019, CBO estimates that the HITECH Act will save the Medicare and Medicaid programs a total of approximately $12.5 billion. Under current law, CBO predicts that approximately 45% of hospitals and 65% of physicians will have adopted HIT by 2019. CBO estimates that the incentive mechanisms in the HITECH Act will boost those adoption rates to approximately 70% for hospitals and 90% for physicians.

The HITECH Act provides financial incentives for HIT use among health care practitioners. It establishes several grant programs to provide funding for investing in HIT infrastructure, purchasing certified EHRs, training, and the dissemination of best practices. E-prescribing functionality is a required component of these EHRs. Important to pediatricians, the legislation further authorizes a 100% federal match for payments to certain qualifying Medicaid service providers who acquire and use certified EHR technology.

E-Prescribing of Controlled Substances

In March 2010, the US Drug Enforcement Agency published the interim final rule on e-prescribing of controlled substances. Before the interim final rule, controlled substances were excluded from e-prescribing through a prohibition by the Drug Enforcement Agency. Even though this ruling will close the gap in e-prescribing, the rules require recertification of systems by outside auditors, new credentialing and auditing processes for prescribers, and a new level of authentication by prescribers before prescriptions are able to be routed electronically. Physicians must apply to federally approved credential service providers or certification authorities to verify their identity and obtain the necessary credentials to engage in e-prescribing of controlled substances. Once a provider is authorized by a third person in the practice to prescribe controlled substances, providers must provide 2 modes of identification, including a user identification/password, a token (like a smart card), or a biometric factor (like a thumbprint) (http://www.deadiversion.usdoj.gov/fed_regs/rules/2010/fr0331.htm). Because of the complexity required to prevent drug diversion (forgeries), vendor compliance and provider adoption is expected to take 1 to 2 years.

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