

TECHNICAL REPORT

Pediatric Aspects of Inpatient Health Information Technology Systems

George R. Kim, MD, Christoph U. Lehmann, MD and the Council on Clinical Information Technology

ABSTRACT

US adoption of health information technology as a path to improved quality of patient care (effectiveness, safety, timeliness, patient-centeredness, efficiency, and equity) has been promoted by the medical community. Children and infants (especially those with special health care needs) are at higher risk than are adults for medical errors and their consequences (particularly in environments in which children are not the primary patient population). However, development and adoption of health information technology tools and practices that promote pediatric quality and patient safety are lagging. Two inpatient clinical processes—medication delivery and patient care transitions—are discussed in terms of health information technology applications that support them and functions that are important to pediatric quality and safety. Pediatricians and their partners (pediatric nurses, pharmacists, etc) must develop awareness of technical and adaptive issues in adopting these tools and collaborate with organizational leaders and developers as advocates for the best interests and safety of pediatric patients. Pediatric health information technology adoption cannot be considered in terms of applications (such as electronic health records or computerized physician order entry) alone but must be considered globally in terms of technical (health information technology applications), organizational (structures and workflows of care), and cultural (stakeholders) aspects of what is best. *Pediatrics* 2008;122:e1287–e1296

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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

health information technology, electronic health record, quality improvement, quality of care, pediatrics

Abbreviations

HIT—health information technology
CPOE—computerized provider order entry
CDS—clinical decision support
EHR—electronic health record
AAP—American Academy of Pediatrics
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INTRODUCTION

US adoption of health information technology (HIT) has been advocated by federal agencies, health care industry groups, and patient-advocacy organizations as a major approach to improve patient safety through reduction and prevention of medical errors.^{1–5} Adoption of HIT tools such as electronic health records (EHRs), computerized provider order entry (CPOE), and clinical decision support (CDS) is increasing, and although current implementation of all these HIT tools is not yet widespread in US hospitals,^{6,7} most hospitals that provide care for children and infants use some form of an electronic information system to manage personal health information and other data that affect children's health.⁸

Children and infants have vulnerabilities and needs that are distinct from adults with regard to the management of their clinical care and its associated information. The extended normal ranges of body weights, sizes, and physiologic responses require modifications of clinical, technical, and information workflows to provide pediatric-specific care that is safe. A systematic evidence base for design and implementation of effective HIT that improves care quality and safety is needed but lacking,⁹ and recent observations and experience indicate that changes (such as the adoption of information technology) can introduce new and unanticipated errors.^{10–12}

MOTIVATIONS

The primary reason for adopting HIT is to improve the quality and safety of care. Information technology can reduce variations that lead to task failures¹³ and uncertainties that increase cognitive burdens that lead to incorrect decisions. An important component in safety is the consideration (and estimation) of risk:

$$\text{risk} = \text{likelihood of error} \times \text{severity of error (harm)}.$$

Children seem to be at higher risk than adults for medical errors, with estimates based on inpatient data suggesting that hospitalized children may be at higher (up to triple) risk of preventable adverse drug events. Contributors to these may include wider ranges of children's and infants' weights (neonates seem to be at the highest risk of adverse drug events), greater complexity of medication dosing (universal weight-based dosing is prone to calculation errors

and must include consideration for adult maximum-dose limits), and higher risk in special domains (continuous intravenous infusions and chemotherapy may have higher immediate and/or cumulative toxicities than other drug types).

Another contributor to children's risk of medical errors is the variety of institutional settings in which they receive medical, surgical, and psychiatric care. Environments range from academic centers that specialize in tertiary pediatric care to general community hospitals that care primarily for adults. Each type of inpatient setting (and each individual setting) has specific attributes that may contribute to error likelihood.

BARRIERS

The major technical barrier to adoption of pediatric HIT tools is a lack of pediatric-specific information technology standards. Among these needs for standards are pediatric data that are machine-readable, terminologies and dictionaries that fully describe pediatric clinical entities (such as pediatric drug-dose data), and electronic standards (Health Level 7 Child Health Functional Profile¹⁴ is currently in development) that adequately describe pediatric clinical events.

To establish these technical standards, there must be recognized leadership and authority as well as legislative and financial support at national, regional, and institutional levels. Standards for HIT products and practices designed for pediatric care must be based on pediatric data, not extrapolated from adult data.⁹ Recent efforts by the American Academy of Pediatrics (AAP) Council on Clinical Information Technology have promoted collaboration to define standard pediatric functionalities for EHRs, and the requirements for pediatrics are being addressed by the Certification Commission for Health Information Technology.¹⁵

STAKEHOLDERS IN PEDIATRIC INPATIENT CARE

The child and family caregivers are central to pediatric care. Health care structures and processes, including errors and their disclosure, must be transparent to patients and families. Inpatient HIT applications must support family-centered, developmentally appropriate care of children¹⁶ and must preserve transparency and patient/family empowerment.

The primary care provider and the medical home are central in the longitudinal care of children, particularly those with special health care needs. Inpatient HIT applications and workflows must support facilitated communication and continuity among patients' primary care providers, families, and inpatient care teams as well as (real-time) interoperability between inpatient and medical home clinical data systems.

Hospitalists and nursing and affiliate staff (such as pharmacists) are central to the inpatient care process. The progressive compartmentalization of health care has separated clinical responsibilities for transitional and inpatient care: emergency physicians for emergent care, hospitalists for general inpatient and observation-unit services, neonatologists and intensivists for critical care

services, specialists for specific problems and procedures, and nursing for inpatient unit management and patient care administration. Inpatient HIT tools must support the work of inpatient staff to organize patient care, facilitate communication, and make care transitions (including shift change, admission, transfer, and discharge) safe while reinforcing staff roles in patient care¹⁷⁻²³ (including issues of training and certification requirements²⁴⁻²⁶ for pediatric care).

WORKFLOWS IN PEDIATRIC INPATIENT CARE

Medication delivery and patient care transitions are 2 inpatient processes that are vulnerable to errors and are the focus of current research and development of information technologies.

Medication Delivery

Medication delivery is a set of common inpatient processes consisting of a series of role-based functions and handoffs. Certain environments and processes have higher risk because of a higher likelihood and/or impact of errors, but at the core:

1. A prescriber determines a patient's need for a drug regimen; specifies a medication and its dosage, form, route, and frequency; and then generates a formal order for the regimen and transcribes it for transmission to the pharmacist.
2. The pharmacist receives and checks the order; consults patient data and the prescriber (when needed) for errors and clarifications; makes certain independent decisions on form, route, and dose adjustments; and prepares and dispenses drug doses and instructions.
3. Drug doses are delivered to the inpatient unit nurse, who accepts and stores the drug doses; retrieves, administers, and documents drug doses to the patient according to the original order/schedule and pharmacy instructions; and makes certain independent decisions within practice scope (such as with "as-needed" orders or optional administration routes [oral versus rectal]).

Inpatient Patient Transitions

During an inpatient stay, patients undergo numerous care transitions, including admission (from emergency departments, transport services, and physician offices), discharge (to home or other facilities), and/or transfer to different locations within the institution for tests (imaging), procedures (surgery), and special levels of care (postanesthesia recovery care). Patients in transit (away from the "home" inpatient unit) may have needs, including life (ventilator) and environmental (temperature regulation for preterm infants) support, maintenance of scheduled and continuous medical care, physical transport, patient-location tracking, and contingencies that must be anticipated and coordinated before transition. Information (in the form of notes, orders, and other documentation) accompanies personnel until the patient reaches his or her destination, where transition (handover) occurs.

The most common transition is the transfer of care responsibilities (handovers, handoffs, or sign-outs). Physicians, nurses, consultants, and ancillary staff members transfer responsibilities in parallel (physician to physician, nurse to nurse, etc) and, in most cases, asynchronously according to shift and call schedules. Higher rates of handovers of information, authorization, and responsibility are associated with higher risks of incomplete or incorrect information transfer but may be necessary because of residency hour requirements.²⁷ Currently identified transition problems include needs for medication reconciliation and structured and interactive information transfers during handovers.

GENERAL CONSIDERATIONS FOR INPATIENT HIT APPLICATIONS

The consideration of adopting HIT for clinical use involves assessments of both the clinical and institutional environment and of available products.

Assessment of the Clinical and Institutional Environment

Within any clinical environment or workflow, HIT adoption is high-risk change that must be managed carefully. In assessing HIT-adoption initiatives, stakeholders should consider HIT applications globally, in terms of the anticipated technical and adaptive changes that will be needed for adoption,²⁸ including the ways that information will be presented, communicated, and used; downtime and recovery procedures; anticipated benefits; and how these changes will be measured. These considerations (plus others, including the political climate for change) and the presence or lack of answers can focus and guide efforts in securing resources and expertise.

Assessment of Information Technology Products

Institutional awareness about specific HIT products gained through interchange with similar institutions can help reduce trial-and-error. Beyond sharing of knowledge about technology (hardware, software, interoperability with other systems, messaging), information assurance (data confidentiality, integrity, and availability), and accessibility/usability requirements (including the ability to override CDS) that a system must meet, institutional leaders involved with HIT decisions should communicate, not only with other institutions but with vendors and workers from all levels involved in using HIT applications. Site visits to external deployments can help decision-makers to gain familiarity with products, to assess a product's applicability to specific work environments, and to learn from the experience of their peers with products, vendors, and the adoption process. A "community-of-practice"²⁹ approach encourages information sharing and dissemination about HIT adoption among practitioners (as well as others) and provides firsthand experiences of current users that can impart information on challenges and shortcomings that new customers need to make informed decisions. Collective formal and informal knowledge forums³⁰ will be needed

for specific applications if informed HIT adoption is to increase.

SPECIFIC HIT APPLICATIONS: CONTEXTS, PURPOSES, FUNCTIONS, AND PEDIATRIC FEATURES

Medication Delivery

Computerized Provider Order Entry

Context, Purpose, and Functions

CPOE³¹ provides support for prescribers at the prescribing/ordering step of the medication-delivery process, with the purpose of standardizing and ensuring completeness in orders for drugs, tests, and procedures. CPOE interfaces promote standardization through default options³² and guide prescribers in creating and formatting structured orders through an electronic interface. CPOE differs from stand-alone prescription writers by an electronic data connection (excluding fax) to a pharmacy information system. In most cases, inpatient CPOE is linked to CDS, which improves its ability to reduce errors.³³

Pediatric-Specific Features

CPOE for pediatric inpatients should provide:

- universal weight/body surface area–based dosing (with standard and consistent units of measurement (eg, metric) to prevent conversion and calculation errors);
- drug dictionaries with pediatric-specific dose ranges and alerts that include single-dose, daily-dose, and cumulative-dose decision support, including lifetime cumulative dose for chemotherapies;
- drug-dosing decision support that is contextual for pediatric-specific health issues that can include neonatal, renal, oncology, and other illness or wellness states;
- automated calculations and automatic dose limits/caps for larger patients;
- medication-reconciliation tools;
- pediatric-specific order sets;
- ability to link vaccination ordering to current immunization schedules; and
- linkage to pediatric-appropriate nutrition, laboratory, radiology, and other ancillary service orders (eg, orders linked to pediatric-specific tests [smaller blood volumes]).

Clinical expertise by pediatricians, pediatric nurses, and pediatric pharmacists familiar with both HIT and pediatrics must guide pediatric CPOE implementation. Specific pediatric medication-delivery processes pose specific challenges in error reduction because of the potential for increased errors or increased impact of errors as follows:

- continuous intravenous infusions, because of the immediate and dynamic impact of administered drugs and complex calculations that change in critically ill patients, benefit from in-line calculators that deter-

mine dosing and appropriate standard concentration choices (per Joint Commission regulations³⁴) of drugs^{35,36};

- pediatric chemotherapy, because of the narrow therapeutic indices and acute and cumulative effects of drugs as well as complex schedules that are prone to interruption as a result of changes in patient condition, is an area of research and development of management and decision-support tools^{37,38}; and
- total parenteral nutrition (a special case of continuous intravenous infusion), because of the complexity of rules and calculations and schedule-critical dependence on timed laboratory results and order, may benefit from in-line calculators with automated rules to avert incorrect dosing, interactions, precipitation of solutes, and other costly errors.³⁹

CDS: Clinical Calculators

Context, Purpose, and Functions

Automated calculation (of drug doses, dates, etc) eliminates manual computation errors, especially in high-stress situations⁴⁰ such as cardiopulmonary resuscitation of a child. For cases in which parameters (such as weight and height) are known, precalculated charts may provide an alternative.⁴¹⁻⁴³ The primary failure point for calculators is manual numerical entry (decimal, unit errors), which must be considered in the design and evaluation of interfaces and user training.

Pediatric-Specific Features

Because possible pediatric weights may vary over orders of magnitude, the wide range of allowed values may facilitate decimal errors and evade detection. Incorporation of independent and redundant checks (automated and human) into workflow to mitigate this type of error is an important consideration of design.

CDS: Electronic Prescribing Systems

Context, Purpose, and Functions

Electronic prescribing systems are designed help clinicians to generate paper or electronic medication prescriptions. The use of CDS, default options, and improved legibility offer the potential for improved patient safety.⁴⁴ In the hospital environment, these applications are usually used in the discharge process.

Pediatric-Specific Features

Features and requirements are similar to the CPOE requirements discussed previously.

CDS: Management Systems

Context, Purpose, and Functions

Management systems can provide high-level decision support by applying clinical and business rules to information processes across different but related systems (such as laboratory, imaging, and hospital admission systems) to improve prevention, therapy, and efficiency. In conjunction with CDS at CPOE interfaces, these tools can provide users with situational awareness of patient

and hospital status. Examples of management tools include electronic whiteboards (census displays),⁴⁵ antimicrobial restriction programs (decision support to reduce inappropriate antibiotic use),⁴⁶ and early notification systems for infection risks for patient cohorting.⁴⁷ The specification of rules requires close interaction of clinicians and developers to specify alerts of high impact and to avoid “alert fatigue.”⁴⁸

Pediatric-Specific Features

Systems have been devised to provide alerts for respiratory syncytial virus and rotavirus.⁴⁹ The extension and linkage of such systems beyond hospitals to public health information systems may have value as resistant organisms previously confined to inpatient settings migrate to the community.^{50,51}

CDS: Reference (or Teaching) Materials

Context, Purpose, and Functions

Automatic or on-demand linkages of patient-specific data (from EHRs)⁵² and general medical knowledge (from formularies or electronic textbooks and handbooks) can aid decisions and help physicians in training.

Pediatric-Specific Features

Application-specific pediatric reference data should be checked by pediatric domain experts for conflicts with accepted norms from trusted data sources. Institutions should decide on “final authority status” of specific resources to resolve discrepancies. Many standard texts and references are available in multiple electronic formats (online, CD-ROM, handheld devices), and availability of trusted pediatric-specific information resources should be coordinated with a pediatrician and a hospital medical librarian. In institutions where children receive care on a partial basis, a core library (which may be available as an online subscription package, either commercially or through organizations such as the AAP or the Centers for Disease Control and Prevention), should be established and maintained. The AAP publishes authoritative policies on most pediatric issues⁵³ and on infectious disease diagnosis and management in children (the *Red Book* online).⁵⁴ The Centers for Disease Control and Prevention publishes current immunization schedules as well as surveillance data for influenza, respiratory syncytial virus, and rotavirus in the *Morbidity and Mortality Weekly Report*.

Pharmacy Information Systems

Context, Purpose, and Functions

Pharmacy information systems⁵⁵ support the dispensing step of the medication-delivery process, with the purpose of providing inventory selection and management and decision support for pharmacists and a redundant check for dosing, drug-allergy, and drug-drug interaction errors and for other pharmacology problems (such as solute precipitation in intravenous solutions). Pharmacology information systems may be linked to or require prompts for data from laboratory information systems (or from previous drug orders) and may be

partially automated (such as in creation of standard-concentration intravenous solutions or parenteral administration solutions).⁵⁶

Pediatric-Specific Features

Because most of the details of pharmacy preparation of drug doses are invisible to prescribers and nurses, the most valuable component of a pediatric pharmacy information system is a qualified and experienced pediatric pharmacist and pharmacy staff⁵⁷ who actively participate in clinical care of inpatients (such as daily work rounds).^{58,59} This expertise provides an additional layer to error catching and safety in medication ordering; however, neither CPOE nor pharmacy information systems may be effective in directly preventing medication-administration errors.⁵⁷ Essential expertise also provided by pediatric pharmacists is knowledge that populates (weight/body surface area) drug-dose range tables and alerts for pediatrics.

Administration Tools: Radio Frequency Identification, Bar Coding, Smart Pumps, Patient-Controlled Anesthesia, and Medication-Administration Records

Context, Purpose, and Functions

The administration step is the last step before a prescribed/ordered medication dose is given to the patient. The substeps of administration (usually performed by a nurse within inpatient environments) include receipt of drug doses from the pharmacy, storage of medication doses before final delivery, scheduled dose retrieval and preparation, identification of patient/drug/dose/form/route (“5 rights”), and final dose delivery. Radio frequency identification^{60–62} and bar-coding^{63,64} systems are used to verify and record identification of patient and drug dose and to track inventory. “Smart” infusion pumps programmed for specific workflows with appropriate drug doses and alerts may be useful in pediatrics⁶⁵ but require caution in deployment because of poor compliance with alerts by human operators.^{66,67} Electronic medication-administration records link administration tools such as radio frequency identification, bar coding, and smart pumps to documentation and tracking of drugs and are used by multiple members of the medical team,⁶⁸ and usability by nursing is an important factor in success.⁶⁹

Pediatric-Specific Aspects

The 2006 Joint Commission mandate for universal use of standardized concentrations in continuous infusion medications⁷⁰ created a debate among pediatric intensivists, particularly neonatologists, about fluid overload in extremely low weight infants. Hierarchical task analysis of neonatal infusion ordering/administration concluded that use of standardized admixtures could be associated with a higher risk of errors than ad hoc (“rule of 6”) admixtures in patients in critical condition who require frequent adjustments in infusion rates.⁷¹ Because of the feedback from this debate, the Joint Commission extended a transition period (until 2008) for pediatric/neonatal acute care if certain safeguards, including the use of “smart” pumps, were in place.^{72,73} A published

description of the implementation process of standard concentrations for neonatal care includes allowances for nonstandard concentrations,⁷⁴ with key knowledge being the lowest infusion rate allowed by the pump.

Errors in expressed human milk administration (wrong mother, wrong infant, wrong milk, wrong expiration date) in the NICU have been described with suggested methodologies for reducing their incidence.^{75,76} In addition to system design to prevent such errors, bar-coding systems have been developed, explored, and advocated⁷⁷ as a means of tracking and ensuring correct administration of human milk.

Certain “high-alert” medications are associated with an increased risk of causing harm to patients⁷⁸ when involved in errors. Approaches to these medications include proactive monitoring and redundant checks to prevent errors⁷⁹ in addition to the use of technology. Pediatric patient-controlled analgesia and patient-controlled analgesia by proxy pose challenges to implementation, and inpatient protocols should be developed in consultation with specialists in pediatric pain control.⁸⁰

Patient Care Transitions

Electronic Health Records

Context, Purpose, and Functions

EHRs are a central structure for patient-specific data documentation. Their multiple roles include facilitating communication among providers, standardizing medical-legal documentation of care, historical record archiving and retrieval, and coordination of care. They can facilitate centralized clinical communication and documentation among hospitalists, primary care providers in medical homes, consultants, and emergency care providers. They also will start to hold artifacts of historical significance over time, such as records of patients who will become persons of public importance as well as historical trends in disease and wellness. They form the basis for medication reconciliation and may support personal health records to inform and empower patients and families about their care. Important technical functions of EHRs include interoperability of data elements, connectivity to other electronic records, and information assurance (according to established standards). Essential in their implementation is effective user training to prevent misuse that may lead to errors.

Pediatric-Specific Features

Pediatric functions in an EHR have been articulated in an AAP policy statement⁸¹ and include:

- immunization management (recording data, linking to immunization systems, decision support);
- growth tracking (graphing and percentile calculation);
- medication dosing (dosing by weight, dose-range checking, safe and convenient dose rounding, age-based decision support, dosing for the school day);
- patient identification (prenatal identifiers, newborn identifiers, name changes, ambiguous gender);

- norms for pediatric data (numeric; nonnumeric; complex normative, such as blood pressures; gestational age); and
- privacy (adolescent, foster/custodial care, consent by proxy, adoption, guardianship, emergency treatment).

Technical standards and certification criteria for inpatient systems are still in development.

Ancillary Information Systems: Laboratory and Radiology (Imaging) Information Systems

Context, Purpose, and Functions

Laboratory and radiology information systems may exist independently or may be integrated with other inpatient information systems. They allow the ordering, managing, processing, billing, and result reporting for laboratory or imaging services. Interoperability and connectivity with inpatient systems (CPOE, EHRs, electronic medication-administration records) is usually limited to single hospitals but may be a safety issue in related institutions that share clinical care of a patient⁸² during a single inpatient stay.

Pediatric-Specific Features

Pediatric-specific features are similar to those outlined for the EHR. Pediatric/age-specific norms for parameters and result reporting for radiologic and laboratory tests are critical.

Ancillary Information Systems: Admission, Discharge, and Transfer Systems

Context, Purpose, and Functions

Admission, discharge, and transfer systems track and facilitate the patient flow throughout the hospital by providing correct and unique patient identifiers for other clinical information technology systems for clinical care and billing.

Pediatric-Specific Features

Pediatric-specific issues that may contribute to increased errors include identification of individual infants in multiple births, mother-infant link, the ability to register patients before arrival (especially for critical and emergency patients), and reconciliation of alerts across information systems.

Standardized Handoffs, Whiteboards, and Patient-Tracking Tools

Context, Purpose, and Functions

Standardized care transitions have been identified as a national patient safety goal.⁸³ Within inpatient settings, types of transitions include:

- admissions and discharges;
- transfers to other units within the same institution; and
- handoffs of care (shift change).⁸⁴

Each transition involves an exchange of information, responsibility, and authority from a provider (or team of

providers) to another and involves a complex interaction of communication and dialogue between the sender and receiver in the transition process. The level of interactivity depends on a variety of factors including the acuity and intensity of care, the uncertainty of the patient's status, the specialty, the level of care, and the experience of the provider (supervising attending, hospitalist, resident, intern). An important aspect of transition is the provision of an appropriate time and location for transition, protected from the interruptive nature of care environments.⁸⁵ Models for handoff transitions and for creating standard checklists and for handoffs have been published.⁸⁶⁻⁸⁸ HIT applications that support the handovers or transfers include electronic patient records, electronic whiteboards, and personal information tools that allow organization, management, and transfer of patient-specific task information.

Pediatric-Specific Features

Drivers for this area of efficiency and patient safety are medication discrepancies at sign-out⁸⁹ and the restriction of resident work hours.^{27,90} A general structured template for transitions developed at an academic pediatric program has been proposed and is based on the mnemonic "PEDIATRIC"⁸⁸:

- Problem list
- Expected tasks to be done
- Diagnostic one-liner
- If/then contingency plans
- Administrative data/advance directive
- Therapeutics
- Results and other important facts
- Intravenous access/invasive devices/procedures
- Custody and consent issues

Other approaches may be preferred in specific specialties or units (such as a systems-based approach used in pediatric and neonatal intensive care).

PRAGMATIC ISSUES

Data Conversion, Accumulation, and Noise

A proposed advantage of electronic data in HIT systems is data reuse.⁹¹ Advantages of electronic data in this regard include reduction of costs and effort of storage and retrieval; however, technical limitations to realizing the full advantage include:

- Current technical ability to convert legacy print information into an electronically usable form. Optical character-recognition technology is limited in its capability to convert handwriting into computer-usable text. Legacy paper documents are typically scanned as photographic images for inclusion into electronic records. Limitations of this format include difficulty searching documents by text matching (other than by reading them) unless documents are labeled. The assignment of scanned records to the correct patient is challenging, and bar-code technologies have been

used to aid in the process.⁹² EHRs may contain many such scanned documents, which are electronically inaccessible and of little added value other than for (manual) searching.

- Default values on clinical forms (such as review of systems and physical examination) are intended to ensure completeness for quality assurance and billing. However, when the printed or retrieved versions of the contents of such forms are generated, very long notes with many negatives (pertinent and extraneous) result in low information “signal-to-noise” ratios and reduce clinical usefulness of form data. The value of notes generated from structured data has been improved with the addition of narrative text,⁹³ which may be richer (or different) than structured data entry.⁹⁴ In addition, “copy-and-paste” behaviors that allow providers to generate notes from previous entries may result in inflated notes and persistent propagation of errors.⁹⁵

Effective solutions are difficult, and considerations should include which product options (such as optical character-recognition conversion) to use and how data-input forms should be designed.

Assurance and Certification

HIT purchasers and clinicians want assurances that the systems they purchase and use will provide needed technical functions and interoperate with other systems securely. To accomplish these goals, public-private processes are in development to define standards for HIT products and evaluate which systems meet them. Efforts aimed at certifying EHRs and their networks (including CPOE) have been implemented by the Certification Commission for Healthcare Information Technology and the Leapfrog Group.^{15,96,97} The current list of certifications for pediatric HIT functions is small (limited to pediatric ambulatory EHRs) but growing.

Liability Risk Modification

The accessibility of data afforded by electronic information systems creates new types of medicolegal liabilities. Increased availability of personal health data from multiple locations creates the potential for information breaches and confidentiality violations. New federal rules extend discovery to electronic information beyond the patient record, including e-mails, electronic business records, archived data, and administrative metadata on the origins and times of records.⁹⁸ Electronic clinical records can facilitate discovery of practice deviations and record alterations,⁹⁹ and converted legacy records, although they may have limited clinical value, may be admissible, although their paper counterparts may have long been discarded.

Ethnic and Minority Populations and Special Health Information Needs

Language and literacy barriers may add to the complexities of care in non-English-speaking populations and may contribute to poor outcomes. Preformatted patient

information sheets may not match the needs of patients,^{100,101} which may be missed by providers. The special needs of these patients and families include cultural competence by providers (including knowledge of language and health literacy issues) and information tools (such as personal health records and information sheets) adjusted to patient needs (including forms and scripts that ensure true informed consent).

For children with special health care needs, special communication needs may include extended discussions to ensure access to timely and appropriate care. An indirect effect of inpatient HIT adoption for minority populations may ultimately be related to the financial barriers of access and where families seek care. Low HIT-implementation rates in institutions where these patients receive care may reflect health disparities that are only part of the complex issues of the effects of poverty on children and their care.¹⁰²

CONCLUSIONS

The adoption, incorporation, and use of HIT in inpatient settings to ensure patient safety where children receive care goes beyond consideration of available technical products. Pediatricians and child health advocates interested in adopting HIT for inpatient care must be aware of the technical and adaptive considerations that go into its successful acquisition, implementation, and deployment.

HIT adoption involves a global consideration of local institutional issues including:

- existing safety problems and outcomes that are to be improved with HIT;
- organizational structure and clinical process changes that will be required, including the work of implementation and the costs of adoption, deployment, use, and maintenance; and
- cultural and political factors that facilitate and block the changes.

Pediatric-specific HIT adoption involves familiarity with collective experience and knowledge.

- Similar institutions with the same problems, experiences, and data can be key in providing input and experiences.
- Specific products, their functions, and pediatric-centered features must be evaluated.
- Shared information resources can be consulted to aid evaluation and decision-making.

HIT adoption involves expertise in clinical informatics among the following:

- pediatric clinicians (physicians, nurses, pharmacists) with information technology experience in analysis, implementation, and evaluation of systems;
- organizational change managers versed in information technology transitions in clinical settings; and
- pediatric and institutional leaders who understand the goals and values of health care improvement and clin-

ical information technology adoption with regard to the health needs of children, including those with special health care needs.

Introduction of HIT may significantly improve clinical performance, reduce costs, and reduce workloads; however, every HIT-system implementation will invariably introduce new and sometimes unforeseen errors and challenges.

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CONTRIBUTORS

Timothy H. Hartzog, MD
Christoph U. Lehmann, MD
Partnership for Policy Implementation

STAFF

Jennifer Mansour

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