Electronic Health Record Adoption by Children's Hospitals in the United States

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Objective: To assess adoption of electronic health records (EHRs) and clinical functionalities, involvement in health information exchange, and barriers to and facilitators of adoption among children's hospitals in the United States.

Design: Survey presented as an information technology supplement to the American Hospital Association's annual member survey.

Setting: General acute care children's hospitals in 2008, identified using the membership directory of the National Association of Children's Hospitals and Related Institutions.

Participants: Chief information officers or equivalent hospital leaders.

Main Exposures: Potential barriers to or facilitators of EHR adoption.

Main Outcome Measures: Rates of EHR adoption, determined using expert-formulated definitions based on presence of essential functionalities, and rates of implementation for individual functionalities and participation in health information exchange.

Results: Of 155 children's hospitals, 108 (69.7%) responded to the survey. Only 2.8% had a comprehensive EHR, whereas an additional 17.9% had a basic system. Adoption of individual functionalities varied widely; comprehensive implementations of computerized provider order entry for medications and many forms of decision support were reported by fewer than half. In all, 15.7% of hospitals exchanged health information electronically. Hospital characteristics were not associated with EHR adoption or participation in health information exchange. Hospitals identified financing as the most important target for policy strategies.

Conclusions: Most children's hospitals lack the minimum functionalities needed for a basic EHR. Ensuring access to adequate financial resources will be critical for inclusion of children's hospitals in efforts to expand EHR use.

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THE PROBLEMS THAT BRING children to the hospital have changed over the past several decades.[1] Chronic disorders, such as asthma, obesity, and behavioral disorders, are increasingly prevalent, whereas severe acute illnesses are less common because of dramatic improvements in prevention and treatment.[1-3] Correspondingly, chronic conditions now account for more than half of pediatric hospitalizations.[1] Because disease management must be tailored to the patient's age, weight, and developmental stage, provision of effective pediatric care is challenging.[4,5] The increasing prominence of complex chronic disorders has further intensified the need for tools that facilitate information management and support decision making.

Electronic health records (EHRs) have the potential to fulfill this need and thereby promote safe and effective care,[6] including in pediatric settings.[7-10] Despite anticipated benefits of EHRs, their implementation by US hospitals has been slow. President Barack Obama and members of both political parties have therefore made adoption and use of health information technology a high priority.[11] Our group recently published results of a national survey of inpatient EHR use, applying precise definitions for basic and comprehensive EHRs based on inclusion of key functionalities.[12] We found that only 1.5% of acute care hospitals had a full set of functionalities implemented across all units, fulfilling the definition of a comprehensive system. Only an additional 7.6% possessed a minimum set of essential functionalities

implemented in at least 1 unit and thus met the definition of a basic system.

Information on EHR adoption specifically by children's hospitals is scarce. These data are of interest, however, because children's hospitals treat more than 1 million, or about one-third, of pediatric inpatients annually and provide most of the care to children with complex conditions.[13] The only previous national survey, performed in 2005, showed that 48.6% of children's hospitals identified themselves as having an EHR.[14] However, the EHR definition used in that study was not provided, which makes tracking adoption of this critical technology among pediatric hospitals difficult and limits comparability to the rest of the hospital sector.

We undertook an evaluation of EHR adoption among US children's hospitals using a definition of an EHR that was specified by a federally sanctioned expert panel. We sought to provide an estimate of EHR diffusion among children's hospitals, a basis for comparison with adult hospitals, and a starting point for tracking adoption over time. Given the limited EHR implementation in hospitals overall, we hypothesized that use by children's hospitals would also be low. Our aims were to determine (1) adoption rates for specific functionalities, such as computerized provider order entry (CPOE) and decision support; (2) rates of EHR adoption; and (3) rates of participation in health information exchange (HIE). We also assessed hospital characteristics as potential correlates of EHR use and characterized the most commonly reported barriers to and facilitators of adoption.

METHODS

SURVEY DEVELOPMENT, SAMPLE, AND ADMINISTRATION

Full details of the survey development and administration were described previously.[12] In brief, our group formulated the initial draft of the survey based on review of previous hospital-based surveys on EHRs or related technologies. We sought feedback from a national group of chief information officers and other hospital leaders. We obtained further recommendations from a panel of experts in health information technology, survey research, health services research, and health policy.

The survey was administered as an information technology supplement to the American Hospital Association's annual member survey and was sent to the chief executive officers of all acute care general medical and surgical member hospitals. The survey was generally completed by a hospital's chief information officer or equivalent. It was initially mailed in March 2008 with a 6-month in-field period. Nonresponding hospitals were contacted multiple times by mail and telephone.

IDENTIFICATION OF CHILDREN'S HOSPITALS

We compiled a list of general acute care children's hospitals from the National Association of Children's Hospitals and Related Institutions (NACHRI) membership directory and used the list to identify children's hospitals among the survey respondents.[13] Rehabilitation and specialty NACHRI hospitals were excluded. The 155 general acute care hospitals included 46 freestanding hospitals and 75 nonfreestanding hospitals, known as "children's hospitals within hospitals." Another 34 hospitals had "associate" membership status, defined by NACHRI

as having a minimum daily pediatric census of 45 and serving as a pediatric referral and teaching facility. A single survey was administered to each institution; children's hospitals within hospitals or large pediatric units did not receive a separate survey. The survey data analysis was considered exempt from human subjects review by the institutional review board of the Harvard School of Public Health.

SURVEY CONTENT

We inquired about implementation of 32 potential clinical functionalities of an EHR system, asking respondents to indicate whether each functionality was implemented in electronic format in all major clinical units or in 1 or more (but not all) units. For functionalities not yet implemented in any unit, we asked whether implementation had begun or was planned. We also inquired about participation in HIE and types of data exchanged. Finally, we asked whether certain issues were barriers to EHR implementation and how potential policy changes would affect adoption.

EHR DEFINITIONS

For this pediatric analysis of EHR use, we applied the same expert-derived definitions of a comprehensive and basic EHR as were used in our previous assessment of all hospitals, thus permitting comparison between children's hospitals and other hospitals.[12] A comprehensive EHR system must include 24 functionalities within the domains of electronic clinical documentation, test and imaging results, CPOE, and decision support implemented in all major clinical units of the hospital (eTable 1; http://www.archpediatrics.com). A basic EHR system must include a subset of 10 functionalities implemented in 1 or more units. The clinical functionalities included in the definitions are universal to health care and have been proposed as necessary for pediatric EHR systems.[4] However, we did not assess functionalities specific to pediatric care that might not be included in EHRs oriented toward adult medicine.

STATISTICAL ANALYSIS

We evaluated bivariate relationships between hospital characteristics and whether a hospital responded to the survey and found that only teaching status was significantly associated: compared with nonresponders, a greater proportion of responding institutions were major teaching hospitals. Using a logistic regression model with hospital characteristics as covariates, we estimated the propensity to respond to the survey and used the reciprocal of this propensity value as a weight in all analyses.

We assessed the proportion of hospitals that had select electronic functionalities and the extent of implementation across hospital units. We also evaluated whether freestanding hospitals and hospitals within hospitals differed in comprehensive adoption of key functionalities. Because hospitals within hospitals did not receive a separate survey from their parent institutions, we did not evaluate partial adoption (ie, in ≥1 but not all units) for this comparison since we could not assess whether pediatric units were among those possessing the functionalities. We instead focused on comprehensive implementation (ie, across all units) to ensure that pediatric units were included.

We calculated EHR adoption rates as the proportion of hospitals that possessed the combination of functionalities defined as constituting a basic or comprehensive EHR. We examined bivariate relationships between hospital characteristics and possession of at least a basic system. We identified the most commonly reported barriers to adoption and noted the policy changes most often identified as encouraging adoption.

Because HIE between hospitals and other providers can be critical to ensuring continuity and coordination of care,[15] we also evaluated children's hospitals' involvement in HIE, defined as active exchange of electronic data by a hospital outside its system. (A hospital could participate in HIE yet not have all the functionalities required to fulfill the basic EHR definition.) We calculated the proportion of hospitals involved in HIE and determined types of data exchanged with ambulatory providers or other hospitals. To identify correlates of HIE participation, we analyzed bivariate associations between hospital characteristics and involvement in HIE.

We used the Fisher exact test and logistic regression for bivariate analyses, and we used logistic regression for multivariate analyses. A 2-sided $P < .05$ was designated as the criterion for statistical significance. All analyses were performed using Stata 9.0 software (StataCorp, College Station, Texas).

RESULTS

SURVEY RESPONDENTS

Of the 155 general acute care NACHRI hospitals surveyed, 108 responded, yielding a response rate of 69.7% (eTable 2). Approximately one-quarter of hospitals were freestanding, and approximately half were hospitals within hospitals (**Table 1**). Most were private nonprofit institutions (82.4%), and 74.1% were major teaching institutions. These characteristics mirrored the overall makeup of general acute care children's hospitals (data not shown).

IMPLEMENTATION OF ELECTRONIC FUNCTIONALITIES

Adoption of electronic functionalities varied widely by type of functionality (**Table 2**). Test and imaging results viewing was most widespread, with comprehensive implementations of laboratory and radiology reports and of radiol-

Table 1. Characteristics of Responding Hospitals

Characteristic	Hospitals, No. (%) (N=108)[a]
Children's hospital type	
Freestanding	28 (25.9)
Hospital within a hospital	53 (49.1)
Associate	27 (25.0)
Size[b]	
Small	33 (30.6)
Large	75 (69.4)
Region	
Northeast	25 (23.1)
Midwest	27 (25.0)
South	39 (36.1)
West	17 (15.7)
Ownership	
Private nonprofit	89 (82.4)
Public	19 (17.6)
Teaching status	
Major teaching	80 (74.1)
Minor or nonteaching	28 (25.9)
Location	
Urban	106 (98.1)
Rural	2 (1.9)

[a] Because of rounding, percentages may not total 100.
[b] We defined a small hospital as having 6 to 399 beds and a large hospital as having 400 beds or more.

Table 2. Select Functionalities and Their Level of Implementation in US Children's Hospitals

	Hospitals, No. (%)[a]			
	Fully Implemented Across All Units	Fully Implemented in ≥1 Unit	Implementation Started or Resources to Implement Identified	No Implementation and No Specific Plans
Electronic clinical documentation				
Medication lists (n=107)	59 (55.7)	20 (18.5)	27 (25.0)	1 (0.7)
Nursing assessments	43 (40.3)	32 (29.4)	31 (28.8)	2 (1.5)
Physician notes	14 (12.5)	40 (38.4)	52 (47.5)	2 (1.6)
Problem lists (n=107)	26 (24.2)	30 (28.8)	48 (44.2)	3 (2.8)
Test and imaging results				
Diagnostic test images (eg, ECG tracing)	65 (60.6)	18 (16.7)	23 (20.8)	2 (2.0)
Diagnostic test results (eg, echo report) (n=107)	85 (80.5)	11 (10.1)	10 (8.3)	1 (1.0)
Laboratory reports (n=106)	105 (99.2)	0	1 (0.8)	0
Radiology images (n=107)	102 (95.4)	4 (3.8)	1 (0.7)	0
Radiology reports	107 (99.2)	0	1 (0.8)	0
Computerized provider order entry				
Medications	36 (34.3)	23 (21.1)	48 (43.9)	1 (0.7)
Decision support				
Clinical guidelines (eg, aspirin for Kawasaki disease) (n=104)	28 (26.7)	24 (23.6)	49 (46.9)	3 (2.7)
Clinical reminders (eg, influenza vaccine)	34 (31.3)	22 (21.1)	48 (43.9)	4 (3.7)
Drug allergy alerts	66 (61.8)	18 (16.6)	24 (21.6)	0
Drug-drug interaction alerts	64 (59.9)	16 (14.8)	28 (25.2)	0
Drug-laboratory interaction alerts (n=105)	44 (42.3)	22 (21.1)	39 (36.6)	0
Drug dosing support (eg, age-based dosing)	47 (44.4)	22 (20.2)	37 (34.4)	1 (1.0)
Bar coding				
Medication administration (n=107)	30 (28.5)	16 (14.2)	59 (55.6)	2 (1.8)

Abbreviations: ECG, electrocardiogram; echo, echocardiogram.
[a] The number of hospitals responding to each question was 108 unless otherwise indicated. Percentages are weighted by the hospitals' propensity to respond to the survey.

Table 3. Comprehensive Implementation of Key Functionalities, by Children's Hospital Type[a]

	Hospitals, No. (%)[b]	
	Freestanding (n=28)	Hospital Within a Hospital (n=53)
Physician notes	2 (6.0)	10 (18.5)
Computerized provider order entry for medications	7 (25.8)	23 (43.5)
Clinical guidelines[c]	6 (21.8)	18 (34.9)
Clinical reminders	8 (27.7)	22 (41.4)
Drug dosing support[d]	9 (31.0)	27 (51.8)
Bar coding for medication administration[e]	6 (21.0)	14 (26.6)

[a] When evaluated using bivariate logistic regression, differences between freestanding hospitals and hospitals within hospitals were not statistically significant.
[b] Percentages are weighted by the hospitals' propensity to respond to the survey.
[c] Only 26 freestanding hospitals and 51 hospitals within hospitals responded to the question about clinical guidelines.
[d] Only 52 hospitals within hospitals responded to the question about drug dosing support.
[e] Only 52 hospitals within hospitals responded to the question about bar coding for medication administration.

Table 4. Health Information Exchange Outside Hospital System, by Hospital Characteristics and Extent of EHR Adoption[a]

	Exchange Health Information, No. (%)[b]
All hospitals (N=108)	**17 (15.7)**
Children's hospital type	
Freestanding (n=28)	4 (14.0)
Hospital within a hospital (n=53)	6 (11.6)
Associate (n=27)	7 (24.9)
Size[c]	
Small (n=33)	6 (18.4)
Large (n=75)	11 (14.7)
Region	
Northeast (n=25)	3 (12.0)
Midwest (n=27)	8 (29.9)
South (n=39)	4 (9.3)
West (n=17)	2 (12.0)
Ownership	
Private nonprofit (n=89)	16 (18.3)
Public (n=19)	1 (5.5)
Teaching	
Major teaching (n=80)	11 (13.8)
Minor or nonteaching (n=28)	6 (22.1)
Extent of EHR adoption	
Comprehensive EHR (n=3)	0
Basic EHR (n=19)	6 (32.7)
No EHR (n=86)	11 (12.4)

Abbreviation: EHR, electronic health record.
[a] When evaluated using bivariate logistic regression, hospital characteristics and extent of EHR adoption were not significantly correlated with participation in health information exchange.
[b] Percentages are weighted by the hospitals' propensity to respond to the survey.
[c] We defined a small hospital as having 6 to 399 beds and a large hospital as having 400 beds or more.

ogy images by 99.2% and 95.4% of hospitals, respectively. Viewing diagnostic test images (such as electrocardiograms) was present across all units in 60.6% of hospitals and in at least 1 unit in an additional 16.7% of hospitals. Other functionalities commonly implemented in all units included drug allergy alerts (61.8%), drug-drug interaction alerts (59.9%), and medication lists (55.7%). Most hospitals (87.8%) reported that their electronic system permitted compilation of a current medication list, whereas 55.4% reported that it enabled comparison between inpatient and preadmission lists and 71.6% that it allowed for creation of an updated list at discharge.

In contrast, relatively few hospitals had comprehensive implementations of other functionalities for electronic clinical documentation or decision support (Table 2). Notably, only 34.3% of hospitals had instituted CPOE for medications in all units, although the others reported at least partial implementation or plans for implementation.

Children's hospitals within hospitals had higher implementation rates for selected key functionalities compared with freestanding hospitals (**Table 3**). Although no comparison was statistically significant, this trend was consistent across all functionalities examined. The most marked differences were observed for drug dosing support (fully implemented in 51.8% of hospitals within hospitals vs 31.0% of freestanding hospitals) and CPOE for medications (43.5% vs 25.8%).

ADOPTION OF EHRs

Although adoption rates were high for several individual functionalities, far fewer hospitals possessed the key combinations of functionalities needed to fulfill the definitions of an EHR. Only 2.8% (95% confidence interval, 0%-6.0%) of hospitals had hospital-wide use of all functionalities needed for a comprehensive EHR system (eTable 3). An additional 17.9% (95% confidence interval, 10.4%-25.3%) had implemented in at least 1 unit the functionalities regarded as the minimum necessary for a basic system. Adoption of a basic system was reported by 18.3% of freestanding hospitals, 14.6% of hospitals within hospitals, and 23.8% of associate hospitals. These differences were not statistically significant. We also found no statistically significant differences in EHR adoption rates by other key hospital characteristics, such as teaching status, region, and ownership. The lack of statistically significant associations may have been due to the small overall number of children's hospitals in the United States and the low proportion with EHR systems (eTable 3).

PARTICIPATION IN HIE

Overall, 15.7% of hospitals reported active participation in HIE outside their own hospital system (**Table 4**). These hospitals shared data at fairly similar rates with both ambulatory providers and other hospitals (eFigure). Each type of data was exchanged by at least 40% of the hospitals that indicated participation in HIE. Neither hospital characteristics nor extent of EHR adoption was significantly associated with HIE involvement on bivariate analysis (Table 4).

BARRIERS TO AND FACILITATORS OF EHR ADOPTION

Among hospitals with no EHR system, the most commonly reported barriers to adoption were inadequate capital for purchase (56.8%), maintenance cost (37.6%), lack of interoperability (35.9%), physician resistance (33.2%), and difficulty meeting organizational needs (29.4%) (**Figure**). The policy changes identified by these hospitals as most likely to have a positive effect on EHR adoption were additional reimbursement for EHR use (85.8%) and financial incentives for implementation (68.6%). Other commonly cited facilitators were technical support for implementation (42.8%), objective EHR evaluations (33.1%), and a list of certified EHR systems (27.8%).

COMMENT

Using a federally funded national survey, we found that only 2.8% of children's hospitals have a comprehensive EHR system, whereas an additional 17.9% have a basic EHR. Computerized provider order entry for medications and decision support, both believed to be vital for improving the quality and safety of care,[5,6] are widely available at only a few hospitals. More than half of children's hospitals report comprehensive implementations of functionalities that facilitate medication management, including drug allergy and drug-drug interaction alerts. However, only 44.4% have drug dosing support, of particular importance in pediatric safety.[4]

One might expect children's hospitals to be at a disadvantage with regard to EHR adoption. However, our results indicate that, although EHR adoption rates are low among children's hospitals, they are slightly better than those of adult hospitals: our group found previously that just 1.5% of all hospitals had comprehensive EHRs and 7.6% had basic systems.[12] In retrospect, our findings are not surprising because most children's hospitals are large urban teaching institutions, all features associated with adoption.[12] These characteristics probably correlate with greater financial resources, essential for meeting the substantial cost of implementing and maintaining EHR systems, as well as greater organizational resources, such as leadership and technical capabilities needed for successfully managing the major change in care delivery that accompanies EHR adoption.[16,17] Academic health centers in particular may possess features that increase the likelihood and appeal of EHR implementation, including integrated care delivery systems; scholarly expertise to address issues such as data codification, privacy, and confidentiality; and an "atmosphere of change" resulting from familiarity with practice innovations and the presence of younger postgraduate trainees.[17]

The rate of EHR adoption did not vary significantly by type of children's hospital, but hospitals within hospitals did appear more likely to have key functionalities compared with freestanding hospitals. Although these differences did not reach statistical significance, they were consistent and, for some functionalities, substantial. The relatively large spread in point estimates invites development of hypotheses regarding possible drivers of these
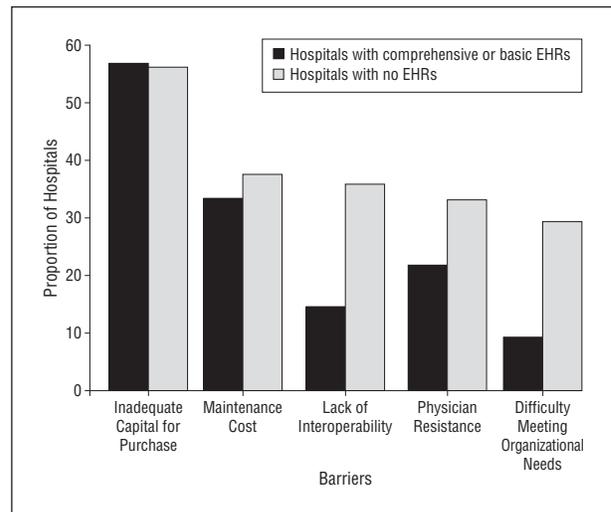

Figure. Differences in reported barriers between hospitals with and without electronic health records (EHRs) were not significant, adjusting for hospital characteristics. However, differences in proportions of hospitals identifying lack of interoperability and difficulty meeting organizational needs as barriers approached statistical significance (P = .08 and P = .06, respectively).

differences. Important factors that might influence adoption include availability of technical support, access to capital, leadership perceptions of the priority of these systems, and the complexity of integrating pediatric features with other systems. Testing these hypotheses will require more detailed data.

Whether the presence of functionalities leads to better pediatric care is uncertain: it is possible that parent institutions may choose institution-wide systems that adequately meet needs of adult patients but lack pediatric features required by hospitals within hospitals. Unfortunately, we could not assess this situation in our survey but hope that future surveys ascertain adoption and use of functionalities that are important to pediatric care. The American Academy of Pediatrics states that EHRs appropriate for pediatric use must incorporate such features as immunization management, growth tracking, age- and weight-based dosing support, and norms for pediatric data.[18] Freestanding hospitals may be implementing electronic functionalities more slowly because they are customizing available products to support pediatric needs.

The 2 most common barriers to EHR adoption identified by children's hospitals were inadequate capital for purchase and maintenance cost. Correspondingly, the most frequently cited facilitators were reimbursement for EHR use and financial incentives for implementation. These responses match the top barriers and facilitators reported by other US hospitals[12] and correspond to findings of other studies.[19] The stimulus package, the American Recovery and Reinvestment Act of 2009, attempts to address these concerns by providing $17 billion of incentives, paid through Medicare or Medicaid, for adoption and use of EHRs.[11] Children's hospitals are eligible for incentives under the Medicaid program even if they care for relatively few Medicaid patients, but the amount of incentives will depend on the proportion of a hospital's inpatient care days that are attributable to Medicaid inpatients.[20] Because 1 in 3 children receives Medicaid

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benefits and children's hospitals provide a substantial proportion of the inpatient care required by these children,[13] these payments could promote EHR implementation by children's hospitals.[21]

Conversely, because so many pediatric patients depend on assistance from Medicaid or the state Children's Health Insurance Program, children's hospitals are most affected by recent and ongoing cuts by state governments to both programs.[22] States indicate that even new federal funds cannot compensate for budget shortfalls and increasing numbers of Medicaid participants.[23] As a result, many children's hospitals have been forced to reduce staff or services for all patients, including those who are privately insured.[22] As children's hospitals struggle to maintain essential programs in the face of these financial challenges, they may be unable to maintain existing technologies or adopt new ones to take advantage of incentives provided by the American Recovery and Reinvestment Act of 2009. We believe that federal policy makers need to work closely with states to ensure that this group of hospitals receives financial resources necessary to adopt electronic systems.

A major barrier to adoption that was identified by children's hospitals but not adult hospitals was the inability of many EHR systems to meet organizational needs.[12] This finding may reflect the lag in development of EHR tools with pediatric-specific features.[4] One important contributing factor is that pediatric information technology standards are still being formulated.[4,24] The initial criteria for meaningful use for the EHR Incentive Program and the certification criteria put forth by the Department of Health and Human Services include some features particularly important for pediatric care, such as growth charts for patients aged 2 to 20 years and immunization records.[20,25] To encourage development and adoption of systems with information management and decision support capabilities across the developmental spectrum and range of child health conditions, policy makers will need to more comprehensively and specifically address pediatric needs in future iterations of criteria. Children's hospitals could apply their expertise to delineate EHR functionalities required for pediatric care and indeed have begun doing so.[26]

Many of our findings correspond to results from the only previous national survey on adoption of health information technology by children's hospitals, conducted by Menachemi and colleagues.[14] The investigators similarly found that laboratory systems were among the most-used functionalities (80.7%) and discovered comparable adoption rates for CPOE (40.4%) and decision support (35.8%). Their conclusions differ, however, on the extent of EHR adoption: their reported rate of 48.6% is more than twice the value of 20.7% obtained by adding the comprehensive and basic EHR adoption rates from our study. This difference may reflect differences in EHR definitions.

Teufel and colleagues[27] reported findings specifically on CPOE implementation based on a 2003 data set of 2145 hospitals that provide pediatric care rather than just institutions classified as children's hospitals under NACHRI criteria. The rate of CPOE use was 6% for the overall sample and 19% for the 91 children's hospitals. Hospi-

tals not included in the data set were assumed not to use CPOE, perhaps accounting at least in part for the lower rate among children's hospitals compared with our finding for CPOE for medications. In addition, the investigators may have assessed different types of CPOE, and the adoption rate may have increased between 2003 and the time of our survey.

Our study had several limitations. Although our response rate was 69.7% and responding and nonresponding hospitals were similar in most characteristics evaluated, responding hospitals were more likely to be major teaching institutions, a feature associated with EHR adoption on previous analysis.[12] We attempted to adjust for nonresponse bias, but our methods may not have accounted for all differences that correlate with adoption. Second, we examined adoption of EHRs but did not evaluate how effectively these systems were being used. Third, although the survey did address functionalities vital for improving quality and safety in the care of all patients, it did not measure whether the systems in place offered features unique to pediatric care. In addition, a separate survey was not provided to children's hospitals within hospitals or large pediatric units at associate hospitals. Finally, our study was limited by low statistical power because of the small number of children's hospitals in the United States and the low rates of EHR adoption among them.

Improving the efficiency and effectiveness of the health care system is a major domestic policy goal, and health information technology promises to serve as a crucial tool in these efforts. Using the instrument and definitions that are currently being applied by the federal government to track EHR adoption by all US hospitals, we found that, although children's hospitals are presently slightly ahead of adult hospitals in adoption, most still lack the combination of core functionalities required for a basic system. Development of applications with pediatric-specific features is needed, together with assessments of how well existing systems function in pediatric care. Furthermore, cuts by state governments to Medicaid and the state Children's Health Insurance Program, both vital funding sources for children's hospitals, threaten to offset federal incentives for EHR implementation. As we devote efforts and invest financial resources toward expanding use of EHR systems, we must ensure that children's hospitals, and the patients they care for, are not left behind.

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REFERENCES

1. Wise PH. The future pediatrician: the challenge of chronic illness. *J Pediatr*. 2007; 151(5)(suppl):S6-S10.

2. Valentine JM, Neff J, Park AN, et al. Pediatric hospitalization patterns for selected chronic health conditions using hospital abstract reporting system data: methods and findings. *Health Serv Outcomes Res Methodol*. 2000;1(3-4):335-350. doi:10.1023/A:1011459629878.

3. Wise PH. The rebirth of pediatrics. *Pediatrics*. 2009;123(1):413-416.

4. Kim GR, Lehmann CU; Council on Clinical Information Technology. Pediatric aspects of inpatient health information technology systems [published correction appears in *Pediatrics*. 2009;123(2):604]. *Pediatrics*. 2008;122(6):e1287-e1296. doi:10.1542/peds.2008-2963.

5. Kaushal R, Bates DW, Landrigan C, et al. Medication errors and adverse drug events in pediatric inpatients. *JAMA*. 2001;285(16):2114-2120.

6. Chaudhry B, Wang J, Wu S, et al. Systematic review: impact of health information technology on quality, efficiency, and costs of medical care. *Ann Intern Med*. 2006;144(10):742-752.

7. Kim GR, Chen AR, Arceci RJ, et al. Error reduction in pediatric chemotherapy: computerized order entry and failure modes and effects analysis. *Arch Pediatr Adolesc Med*. 2006;160(5):495-498.

8. Fiks AG, Grundmeier RW, Biggs LM, Localio AR, Alessandrini EA. Impact of clinical alerts within an electronic health record on routine childhood immunization in an urban pediatric population. *Pediatrics*. 2007;120(4):707-714.

9. Yu F, Salas M, Kim YI, Menachemi N. The relationship between computerized physician order entry and pediatric adverse drug events: a nested matched case-control study. *Pharmacoepidemiol Drug Saf*. 2009;18(8):751-755.

10. Johnson KB, Davison CL. Information technology: its importance to child safety. *Ambul Pediatr*. 2004;4(1):64-72.

11. Blumenthal D. Stimulating the adoption of health information technology. *N Engl J Med*. 2009;360(15):1477-1479.

12. Jha AK, DesRoches CM, Campbell EG, et al. Use of electronic health records in U.S. hospitals. *N Engl J Med*. 2009;360(16):1628-1638.

13. NACHRI. National Association of Children's Hospitals and Related Institutions Web site. http://www.childrenshospitals.net/AM/Template.cfm?Section=Homepage&Template=/customSource/homepage/homepage.cfm. Accessed April 20, 2009.

14. Menachemi N, Brooks RG, Schwalenstocker E, Simpson L. Use of health information technology by children's hospitals in the United States. *Pediatrics*. 2009; 123(suppl 2):S80-S84.

15. Hinman AR, Davidson AJ. Linking children's health information systems: clinical care, public health, emergency medical systems, and schools. *Pediatrics*. 2009; 123(suppl 2):S67-S73.

16. Kazley AS, Ozcan YA. Organizational and environmental determinants of hospital EMR adoption: a national study. *J Med Syst*. 2007;31(5):375-384.

17. Retchin SM, Wenzel RP. Electronic medical record systems at academic health centers: advantages and implementation issues. *Acad Med*. 1999;74(5):493-498.

18. Spooner SA; Council on Clinical Information Technology, American Academy of Pediatrics. Special requirements of electronic health record systems in pediatrics. *Pediatrics*. 2007;119(3):631-637.

19. Poon EG, Blumenthal D, Jaggi T, Honour MM, Bates DW, Kaushal R. Overcoming barriers to adopting and implementing computerized physician order entry systems in U.S. hospitals. *Health Aff (Millwood)*. 2004;23(4):184-190. doi:10.1377/hlthaff.23.4.184.

20. Centers for Medicare & Medicaid Services (CMS), HHS. Medicare and Medicaid programs; electronic health record incentive program: final rule. *Fed Regist*. 2010; 75(144):44313-44588.

21. MacTaggart P, Bagley B. Policy and system strategies in promoting child health information systems, including the role of Medicaid, the State Children's Health Insurance Program, and public financing. *Pediatrics*. 2009;123(suppl 2):S111-S115.

22. Fuhrmans V. Children suffer as states cut health budgets. *Wall Street Journal*. June 17, 2009:D1.

23. Brand R. Medicaid: under the weather: states are facing growing numbers of people in need of medical care, and even billions from the economic recovery package will not solve all their problems. *State Legis*. 2009;35(4):12-16.

24. Spooner SA, Classen DC. Data standards and improvement of quality and safety in child health care. *Pediatrics*. 2009;123(suppl 2):S74-S79.

25. Office of the National Coordinator for Health Information Technology, Department of Health and Human Services. Health information technology: initial set of standards, implementation specifications, and certification criteria for electronic health record technology: interim final rule. *Fed Regist*. 2010;75(8):2013-2047.

26. National Association of Children's Hospitals. Medicare and Medicaid programs; electronic health record incentive program; proposed rule: final comments on meaningful use. March 15, 2010. http://www.childrenshospitals.net/AM/Template.cfm?Section=Quality_Health_IT2&TEMPLATE=/CM/ContentDisplay.cfm&CONTENTID=51254. Accessed April 4, 2010.

27. Teufel RJ II, Kazley AS, Basco WT Jr. Early adopters of computerized physician order entry in hospitals that care for children: a picture of US health care shortly after the Institute of Medicine reports on quality. *Clin Pediatr (Phila)*. 2009;48 (4):389-396.

> You can set yourself up to be sick, or you can choose to stay well.
> —Wayne Dyer