SPECIAL ARTICLE

Use of Electronic Health Records in U.S. Hospitals

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ABSTRACT

BACKGROUND

Despite a consensus that the use of health information technology should lead to more efficient, safer, and higher-quality care, there are no reliable estimates of the prevalence of adoption of electronic health records in U.S. hospitals.

METHODS

We surveyed all acute care hospitals that are members of the American Hospital Association for the presence of specific electronic-record functionalities. Using a definition of electronic health records based on expert consensus, we determined the proportion of hospitals that had such systems in their clinical areas. We also examined the relationship of adoption of electronic health records to specific hospital characteristics and factors that were reported to be barriers to or facilitators of adoption.

RESULTS

On the basis of responses from 63.1% of hospitals surveyed, only 1.5% of U.S. hospitals have a comprehensive electronic-records system (i.e., present in all clinical units), and an additional 7.6% have a basic system (i.e., present in at least one clinical unit). Computerized provider-order entry for medications has been implemented in only 17% of hospitals. Larger hospitals, those located in urban areas, and teaching hospitals were more likely to have electronic-records systems. Respondents cited capital requirements and high maintenance costs as the primary barriers to implementation, although hospitals with electronic-records systems were less likely to cite these barriers than hospitals without such systems.

CONCLUSIONS

The very low levels of adoption of electronic health records in U.S. hospitals suggest that policymakers face substantial obstacles to the achievement of health care performance goals that depend on health information technology. A policy strategy focused on financial support, interoperability, and training of technical support staff may be necessary to spur adoption of electronic-records systems in U.S. hospitals.

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The U.S. health care system faces challenges on multiple fronts, including rising costs and inconsistent quality.[1-3] Health information technology, especially electronic health records, has the potential to improve the efficiency and effectiveness of health care providers.[4,5] Methods to speed the adoption of health information technology have received bipartisan support among U.S. policymakers, and the American Recovery and Reinvestment Act of 2009 has made the promotion of a national, interoperable health information system a priority. Despite broad consensus on the potential benefits of electronic health records and other forms of health information technology, U.S. health care providers have been slow to adopt them.[6,7] Using a well-specified definition of electronic health records in a recent study, we found that only 17% of U.S. physicians use either a minimally functional or a comprehensive electronic-records system.[8]

Prior data on hospitals' adoption of electronic health records or key functions of electronic records (e.g., computerized provider-order entry for medications) suggest levels of adoption that range between 5%[9] and 59%.[10] This broad range reflects different definitions of what constitutes an electronic health record,[10,11] use of convenience samples,[12] and low survey response rates.[13] To provide more precise estimates of adoption of electronic health records among U.S. hospitals, the Office of the National Coordinator for Health Information Technology of the Department of Health and Human Services commissioned a study to measure current levels of adoption to facilitate tracking of these levels over time.

As in our previous study,[8] we identified key clinical functions to define the minimum functionalities necessary to call a system an electronic-records system in the hospital setting. We also defined an advanced configuration of functionalities that might be termed a comprehensive electronic-records system. Our survey then determined the proportion of U.S. hospitals reporting the use of electronic health records for either of these sets of functionalities. We hypothesized that large hospitals would have a higher prevalence of adoption of electronic health records than smaller hospitals. Similarly, we hypothesized that major teaching hospitals would have a higher prevalence of adoption than nonteaching hospitals and private hospitals a higher prevalence than public hospitals. Finally, to guide policymakers, we sought to identify frequently reported barriers to adoption and potential mechanisms for facilitating it.

METHODS

SURVEY DEVELOPMENT

We developed our survey by examining and synthesizing prior hospital-based surveys of electronic-records systems or related functionalities (e.g., computerized provider-order entry) that have been administered in the past 5 years.[9,13,14] Working with experts who had led hospital-based surveys, we developed an initial draft of the instrument. To get feedback, we shared the survey with chief information officers, other hospital leaders, and survey experts. We then obtained input from a consensus panel of experts in the fields of health information technology, health services research, survey research, and health policy. Further survey modifications were approved by our expert panel. The final survey instrument was approved for use by the institutional review board of Partners HealthCare.

SURVEY SAMPLE AND ADMINISTRATION

We collaborated with the American Hospital Association (AHA) to survey all acute care general medical and surgical member hospitals. The survey was presented as an information technology supplement to the association's annual survey of members, and like the overall AHA questionnaire, was sent to the hospital's chief executive officer. Hospital chief executive officers generally assigned the most knowledgeable person in the institution (in this case, typically the chief information officer or equivalent) to complete the survey. Nonresponding hospitals received multiple telephone calls and reminder letters asking them to complete the survey. The survey was initially mailed in March 2008, and our in-field period ended in September 2008.

SURVEY CONTENT

We asked respondents to report on the presence or absence of 32 clinical functionalities of an electronic-records system and on whether their hospital had fully implemented these functionalities in all major clinical units, had implemented them in one or more (but not all) major clinical units, or had not yet fully implemented them in any unit

in the hospital. We asked respondents to identify whether certain factors were major or minor barriers or were not barriers to the adoption of an electronic-records system and whether specific policy changes would have a positive or negative effect on their decision to adopt such a system. The questions and response categories used are listed in the Supplementary Appendix, available with the full text of this article at NEJM.org.

MEASURES OF ELECTRONIC-RECORDS USE

The Institute of Medicine has developed a comprehensive list of the potential functionalities of an inpatient electronic health record,[15] but there is no consensus on what functionalities constitute the essential elements necessary to define an electronic health record in the hospital setting. Therefore, we used the expert panel described earlier to help define the functionalities that constitute comprehensive and basic electronic-records systems in the hospital setting. The panel was asked to identify whether individual functionalities would be necessary to classify a hospital as having a comprehensive or basic electronic health record. With the use of a modified Delphi process, the panel reached a consensus on the 24 functions that should be present in all major clinical units of a hospital to conclude that it had a comprehensive electronic-records system.[16] Similarly, the panel reached a consensus on eight functionalities that should be present in at least one major clinical unit (e.g., the intensive care unit) in order for the hospital to be classified as having a basic electronic-records system. Because the panel disagreed on the need for two additional functionalities (physicians' notes and nursing assessments) to classify a hospital as having a basic system, we developed two definitions of a basic electronic-records system, one that included functionalities for nursing assessments and physicians' notes and another that did not. We present the results with the use of both definitions.

STATISTICAL ANALYSIS

We compared the characteristics of respondent and nonrespondent hospitals and found modest but significant differences. We estimated the propensity to respond to the survey with the use of a logistic-regression model that included all these characteristics and used the inverse of this propensity value as a weight in all analyses.

We examined the proportion of hospitals that had each of the individual functionalities and subsequently calculated the prevalence of adoption of an electronic-records system, using three definitions of such a system: comprehensive, basic with physicians' and nurses' notes, and basic without physician and nursing notes. For all subsequent analyses, we used the definition of basic electronic health records that included clinicians' notes.

We explored bivariate relationships between key hospital characteristics (size, U.S. Census region, ownership, teaching status, urban vs. rural location, and presence or absence of markers of a high-technology institution) and adoption of a basic or comprehensive electronic-records system. We considered the use of various potential markers of a high-technology institution, including the presence of a dedicated coronary care unit, a burn unit, or a positron-emission tomographic scanner. Because the results were similar for each of these markers, we present data based on the presence or absence of only one — a dedicated coronary care unit. We subsequently built a multivariable model to calculate levels of adoption of electronic-records systems, adjusted according to these hospital characteristics. We present the unadjusted results below and those from the multivariate models in the Supplementary Appendix.

Finally, we built logistic-regression models (adjusting for the hospital characteristics mentioned above) to assess whether the presence or absence of electronic health records was associated with respondents' reports of the existence of specific barriers and facilitators of adoption. Since the number of hospitals with comprehensive electronic-records systems was small, we combined hospitals with comprehensive systems and those with basic electronic-records systems and compared their responses with those from institutions without electronic health records. In all analyses, two-sided P values of less than 0.05 were considered to indicate statistical significance.

RESULTS

We received responses from 3049 hospitals, or 63.1% of all acute care general hospitals that were surveyed. After excluding federal hospitals and those located outside the 50 states and the District of Columbia, we were left with 2952 institutions. There were modest differences between re-

Table 1. Characteristics of Responding and Nonresponding U.S. Acute Care Hospitals, Excluding Federal Hospitals.*

Characteristic	Respondents (N=2952)	Nonrespondents (N=1862)
	percent	
Size		
Small (6–99 beds)	48	50
Medium (100–399 beds)	43	43
Large (≥400 beds)	10	7
Region		
Northeast	14	12
Midwest	33	24
South	37	41
West	17	22
Ownership status		
For-profit hospital	14	22
Private nonprofit hospital	62	55
Public hospital	24	23
Teaching status		
Major teaching hospital	7	4
Minor teaching hospital	16	16
Nonteaching hospital	77	80
Member of hospital system		
Yes	43	47
No	57	53
Location		
Urban	62	60
Nonurban	38	40
Dedicated coronary care unit†		
Yes	35	25
No	65	75

* P<0.05 for all comparisons. Numbers may not add to 100 because of rounding.
† The presence of a coronary care unit is a marker of technological capability.

spondents and nonrespondents (Table 1), and all results reported below have been adjusted for potential nonresponse bias.

ADOPTION OF CLINICAL FUNCTIONALITIES IN ELECTRONIC FORMAT

We found large variations in the implementation of key clinical functionalities across U.S. hospitals. Only 12% of hospitals had instituted electronic physicians' notes across all clinical units, and computerized provider-order entry for medications was reported as having been implemented across all clinical units in 17% of hospitals (Table 2). In contrast, more than 75% of hospitals reported adoption of electronic laboratory and radiologic reporting systems. A sizable number of hospitals reported having implemented several key functionalities in one or more (but not all) units, having begun such implementation, or having identified resources for the purpose of such implementation. These functionalities included physicians' notes (among 44% of the hospitals) and computerized provider-order entry (38%).

ADOPTION OF ELECTRONIC RECORDS

The presence of certain individual functionalities was considered necessary for an electronic-records system to be defined as comprehensive or basic by our expert panel (Table 3). On the basis of these definitions, we found that 1.5% (95% confidence interval [CI], 1.1 to 2.0) of U.S. hospitals had a comprehensive electronic-records system implemented across all major clinical units and an additional 7.6% (95% CI, 6.8 to 8.1) had a basic system that included functionalities for physicians' notes and nursing assessments in at least one clinical unit. When defined without the requirement for clinical notes, a basic electronic-records system was found in 10.9% of hospitals (95% CI, 9.7 to 12.0). If we include federal hospitals run by the Veterans Health Administration (VHA), the proportion of hospitals with comprehensive electronic-records systems increases to 2.9% (95% CI, 2.3 to 3.5), the proportion with basic systems that include clinicians' notes increases to 7.9% (95% CI, 6.9 to 8.8), and the proportion with basic systems that do not include clinicians' notes increases to 11.3% (95% CI, 10.2 to 12.5).

Hospitals were more likely to report having an electronic-records system if they were larger institutions, major teaching hospitals, part of a larger hospital system, or located in urban areas and if they had dedicated coronary care units (Table 4); these differences were small. We found no relationship between ownership status and level of adoption of electronic health records: the prevalence of electronic-records systems in public hospitals was similar to that in private institutions. Even when we compared for-profit with nonprofit (public and private) institutions, there were no significant differences in adoption. In multivariable analyses, each of these differences diminished

Table 2. Selected Electronic Functionalities and Their Level of Implementation in U.S. Hospitals.

Electronic Functionality	Fully Implemented in All Units	Fully Implemented in at Least One Unit	Implementation Begun or Resources Identified*	No Implementation, with No Specific Plans
	percent of hospitals			
Clinical documentation				
Medication lists	45	17	18	20
Nursing assessments	36	21	18	24
Physicians' notes	12	15	29	44
Problem lists	27	17	23	34
Test and imaging results				
Diagnostic-test images (e.g., electrocardiographic tracing)	37	11	19	32
Diagnostic-test results (e.g., echocardiographic report)	52	10	15	23
Laboratory reports	77	7	7	9
Radiologic images	69	10	10	10
Radiologic reports	78	7	7	8
Computerized provider-order entry				
Laboratory tests	20	12	25	42
Medications	17	11	27	45
Decision support				
Clinical guidelines (e.g., beta-blockers after myocardial infarction)	17	10	25	47
Clinical reminders (e.g., pneumococcal vaccine)	23	11	24	42
Drug-allergy alerts	46	15	16	22
Drug–drug interaction alerts	45	16	17	22
Drug–laboratory interaction alerts (e.g., digoxin and low level of serum potassium)	34	14	21	31
Drug-dose support (e.g., renal dose guidance)	31	15	21	33

* These hospitals reported that they were either beginning to implement the specified functionality in at least one unit or had identified the resources required for implementation in the next year.

further and was less consistently significant (see the Supplementary Appendix).

BARRIERS TO AND FACILITATORS OF ELECTRONIC-RECORDS ADOPTION

Among hospitals without electronic-records systems, the most commonly cited barriers were inadequate capital for purchase (74%), concerns about maintenance costs (44%), resistance on the part of physicians (36%), unclear return on investment (32%), and lack of availability of staff with adequate expertise in information technology (30%) (Fig. 1). Hospitals that had adopted electronic-records systems were less likely to cite four of these five concerns (all except physicians' resistance) as major barriers to adoption than were hospitals that had not adopted such systems (Fig. 1).

Most hospitals that had adopted electronic-records systems identified financial factors as having a major positive effect on the likelihood of adoption: additional reimbursement for electronic health record use (82%) and financial incentives

Table 3. Electronic Requirements for Classification of Hospitals as Having a Comprehensive or Basic Electronic-Records System.*

Requirement	Comprehensive EHR System	Basic EHR System with Clinician Notes	Basic EHR System without Clinician Notes
Clinical documentation			
Demographic characteristics of patients	√	√	√
Physicians' notes	√	√	
Nursing assessments	√	√	
Problem lists	√	√	√
Medication lists	√	√	√
Discharge summaries	√	√	√
Advanced directives	√		
Test and imaging results			
Laboratory reports	√	√	√
Radiologic reports	√	√	√
Radiologic images	√		
Diagnostic-test results	√	√	√
Diagnostic-test images	√		
Consultant reports	√		
Computerized provider-order entry			
Laboratory tests	√		
Radiologic tests	√		
Medications	√	√	√
Consultation requests	√		
Nursing orders	√		
Decision support			
Clinical guidelines	√		
Clinical reminders	√		
Drug-allergy alerts	√		
Drug–drug interaction alerts	√		
Drug–laboratory interaction alerts (e.g., digoxin and low level of serum potassium)	√		
Drug-dose support (e.g., renal dose guidance)	√		
Adoption level — % of hospitals (95% CI)	1.5 (1.1–2.0)	7.6 (6.8–8.1)	10.9 (9.7–12.0)

* A comprehensive electronic-health-records (EHR) system was defined as a system with electronic functionalities in all clinical units. A basic electronic-records system was defined as a system with electronic functionalities in at least one clinical unit.

for adoption (75%). Other facilitators of adoption included the availability of technical support for the implementation of information technology (47%) and objective third-party evaluations of electronic health record products (35%). Hospitals with and those without electronic-records systems were equally likely to cite these factors (P>0.10 for each comparison) (Fig. 2).

Table 4. Adoption of Comprehensive and Basic Electronic-Records Systems According to Hospital Characteristics.*

Characteristic	Comprehensive EHR System	Basic EHR System†	No EHR System	Overall P Value
		percent of hospitals		
Size				<0.001
Small (6–99 beds)	1.2±0.3	4.9±0.6	93.9±0.6	
Medium (100–399 beds)	1.7±0.4	8.1±0.8	90.2±0.8	
Large (≥400 beds)	2.6±0.9	15.9±2.2	81.5±2.3	
Region				0.77
Northeast	1.1±0.5	8.9±1.4	90.1±1.5	
Midwest	1.7±0.4	6.6±0.8	91.7±0.9	
South	1.4±0.4	7.3±0.8	91.3±0.8	
West	1.9±0.6	7.0±1.2	91.1±1.3	
Profitability status				0.08
For-profit hospital	1.3±0.5	5.2±1.1	93.5±1.2	
Private nonprofit hospital	1.5±0.3	8.4±0.6	90.1±0.7	
Public hospital	1.7±0.5	5.8±0.9	92.4±1.0	
Teaching status				<0.001
Major teaching hospital	2.6±1.1	18.5±2.6	78.9±2.7	
Minor teaching hospital	2.4±0.7	10.6±1.4	87.0±1.6	
Nonteaching hospital	1.3±0.2	5.6±0.5	93.1±0.5	
Member of hospital system				0.006
Yes	2.1±0.4	8.4±0.9	89.5±0.9	
No	1.1±0.2	6.3±0.6	92.6±0.6	
Location				<0.001
Urban	1.9±0.3	8.4±0.6	89.7±0.6	
Nonurban	0.6±0.3	4.0±0.7	95.3±0.8	
Dedicated coronary care unit‡				0.002
Yes	1.9±0.4	9.7±0.9	88.4±1.0	
No	1.3±0.3	6.3±0.6	92.4±0.6	

* Plus–minus values are means ±SE. EHR denotes electronic health record.
† The definition of a basic system that included functionalities for physicians' notes and nursing assessments was used for this analysis.
‡ The presence of a coronary care unit is a marker of technological capability.

DISCUSSION

We found that less than 2% of acute care hospitals have a comprehensive electronic-records system, and that, depending on the definition used, between 8 and 12% of hospitals have a basic electronic-records system. With the use of the definition that requires the presence of functionalities for physicians' notes and nursing assessments, information systems in more than 90% of U.S. hospitals do not even meet the requirement for a basic electronic-records system.

Although levels of adoption of electronic health records were low, many functionalities that underlie electronic-records systems have been widely implemented. A sizable proportion of hospitals reported that laboratory and radiologic reports, radiologic images, medication lists, and some decision-support functions are available in electronic format. Others reported that they planned to upgrade their information systems to an electronic-records system by adding functionalities, such as computerized provider-order entry, physicians' notes, and nursing assessments. However, these

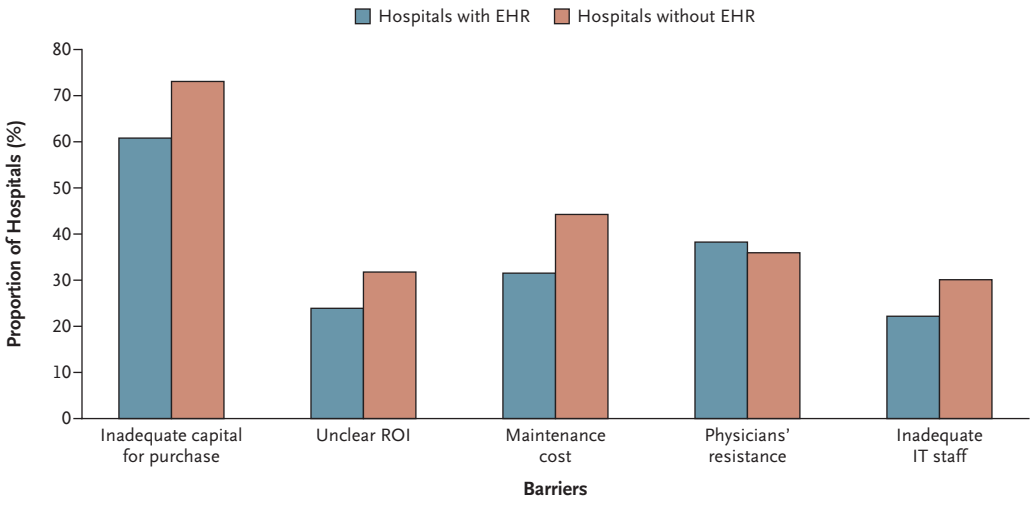

Figure 1. Major Perceived Barriers to Adoption of Electronic Health Records (EHRs) among Hospitals with Electronic-Records Systems as Compared with Hospitals without Systems.

Hospitals with electronic-records systems include hospitals with a comprehensive electronic-records system and those with a basic electronic-records system that includes functionalities for physicians' notes and nursing assessments. P<0.01 for all comparisons except physicians' resistance (P=0.20). IT denotes information technology, and ROI return on investment.

functionalities are typically more difficult to implement than the others that we examined, and it remains unclear whether hospitals will be able to do so successfully.

We found high levels of decision support in the absence of a comparable prevalence of computerized provider-order entry. It is possible that respondents reporting that their hospitals have implemented electronic decision support were including in that category decision-support capabilities that are available only for electronic pharmacy systems, thereby overstating the preparedness of hospitals to provide physicians with electronic decision support for patient care.

We found somewhat higher levels of adoption among larger, urban, teaching hospitals, probably reflecting greater availability of the financial resources necessary to acquire an electronic-records system. We expected to find lower levels of adoption among public hospitals, which might be financially stressed and therefore less able to purchase these systems. Although our results do not support this hypothesis, we did not directly examine detailed indicators of the financial health of the hospitals, such as their operating margins.

In 2006, we performed a comprehensive review of the literature on hospital adoption of electronic-records systems in the United States and found that the most rigorous assessment made was for computerized provider-order entry and that its prevalence was between 5 and 10%.[6,9,14] An earlier AHA survey showed a higher prevalence of computerized provider-order entry,[13] but the response rate was only 19%. A Mathematica survey showed that 21% of U.S. hospitals had computerized provider-order entry and 59% had electronic clinical documentation.[10] However, this survey's definition of clinical documentation allowed for the inclusion of systems that were only capable of recording demographic characteristics of patients, a definition that is likely to have inflated adoption levels, given that Medicare requires electronic reporting of demographic data. A recent analysis, based on a proprietary database with an unclear sampling frame and an unknown response rate, showed that 13% of the hospitals had implemented computerized provider-order entry, a prevalence similar to that in our study.[11]

Most reports of a beneficial effect of electronic-records systems involved systems capable of computerized provider-order entry with clinical-decision support.[4] Our experts took a lenient approach by not requiring the presence of clinical-decision support as part of a basic electronic-records system and by requiring adoption of computerized provider-order entry in only one clinical unit.

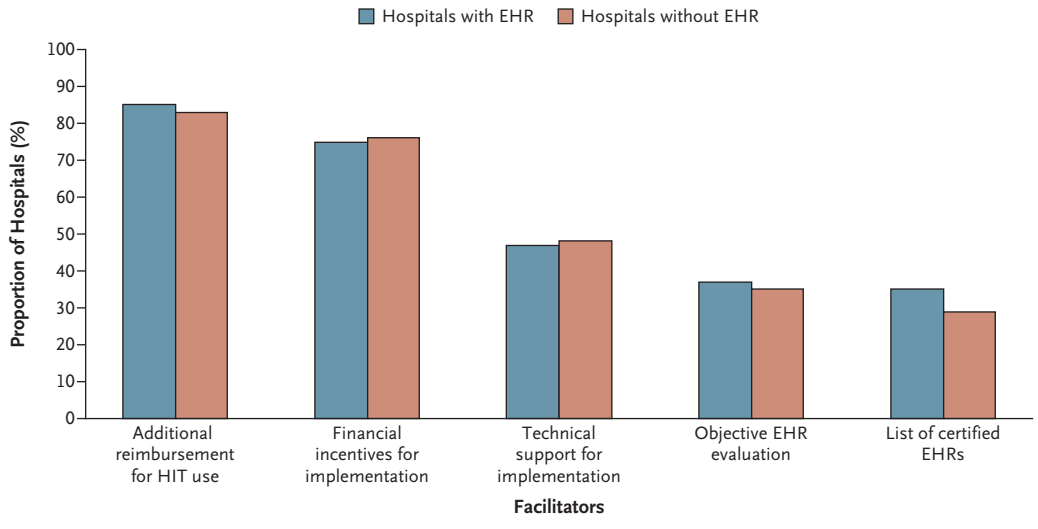

Figure 2. Perceived Facilitators of Adoption of Electronic-Records Systems among Hospitals with Systems as Compared with Hospitals without Systems.

Hospitals with electronic-records systems include hospitals with a comprehensive system and those with a basic system that includes functionalities for physicians' notes and nursing assessments. P>0.10 for all comparisons. EHR denotes electronic health record, and HIT health information technology.

Whether a hospital that has successfully implemented computerized provider-order entry in one unit can easily implement in other units and add clinical-decision support is unclear. Furthermore, a nonuniform information system within the hospital (paper-based in some units and electronic in others) may increase clinical hazards as patients move from one unit to another. Whether the benefits of adoption of an electronic-records system in some clinical units outweigh the theoretical hazards posed by uneven adoption within the hospital requires examination.

Respondents identified financial issues as the predominant barriers to adoption, dwarfing issues such as resistance on the part of physicians. Other studies have shown that physicians' resistance, partly driven by concerns about negative effects of the use of electronic health records on clinical productivity,[17] can be detrimental to adoption efforts.[18] Whether our respondents, most of whom have not adopted electronic health records, underestimated the challenges of overcoming this barrier or whether physicians are becoming more receptive to adoption is unclear. Either way, obtaining the support of physicians — often by getting the backing of clinical leaders — can be helpful in ensuring successful adoption.[19]

Another potential barrier to adoption is concern about interoperability: few electronic-records systems allow for easy exchange of clinical data between hospitals or from hospitals to physicians' offices. Low levels of health information exchange in the marketplace[20,21] reduce the potential value of these systems and may have a dampening effect on adoption.

From a policy perspective, our data suggest that rewarding hospitals — especially financially vulnerable ones — for using health information technology may play a central role in a comprehensive approach to stimulating the spread of hospital electronic-records systems. Creating incentives for increasing information-technology staff and harmonizing information-technology standards and creating disincentives for not using such technology may also be helpful approaches.

Some providers, such as the VHA, have successfully implemented electronic-records systems. VHA hospitals have used electronic health records for more than a decade with dramatic associated improvements in clinical quality.[22,23] Their medical records are nearly wholly electronic, and including them in our analyses led to a doubling of our count of U.S. hospitals with a comprehensive system. Some developed countries, such as the United Kingdom and the Netherlands, have also successfully spurred adoption of health information tech-

nology, although most of their progress has been in ambulatory care. Few countries have yet to make substantial progress in the inpatient setting.[24]

There are limitations to our study. First, although we achieved a 63% response rate, the hospitals that did not respond to our survey were somewhat different from those that did respond. We attempted to compensate for these differences by adjusting for potential nonresponse bias, but such adjustments are imperfect. Given that nonresponding hospitals were more likely to have characteristics associated with lower levels of adoption of electronic health records, residual bias may have led us to overestimate adoption levels. Second, we focused on adoption and could not accurately gauge the actual use or effectiveness of electronic-records systems. Third, we did not ascertain whether the systems that were adopted had been independently certified (by parties such as the Certification Commission for Health Information Technology). Fourth, given low adoption levels, we had limited power to identify predictors of the adoption of comprehensive electronic-records systems as compared with basic systems. Finally, we did not ascertain whether users of electronic health records were satisfied with them.

In summary, we examined levels of electronic health record adoption in U.S. hospitals and found that very few have a comprehensive electronic system for recording clinical information and that only a small minority have even a basic system. However, many institutions have parts of an electronic-records system in place, suggesting that policy interventions could increase the prevalence of electronic health records in U.S. hospitals faster than our low adoption levels might suggest. Critical strategies for policymakers hoping to promote the adoption of electronic health records by U.S. hospitals should focus on financial support, interoperability, and training of information technology support staff.

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