

SPECIAL ARTICLE

Electronic Health Records in Ambulatory Care — A National Survey of Physicians

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ABSTRACT

BACKGROUND

Electronic health records have the potential to improve the delivery of health care services. However, in the United States, physicians have been slow to adopt such systems. This study assessed physicians' adoption of outpatient electronic health records, their satisfaction with such systems, the perceived effect of the systems on the quality of care, and the perceived barriers to adoption.

METHODS

In late 2007 and early 2008, we conducted a national survey of 2758 physicians, which represented a response rate of 62%. Using a definition for electronic health records that was based on expert consensus, we determined the proportion of physicians who were using such records in an office setting and the relationship between adoption and the characteristics of individual physicians and their practices.

RESULTS

Four percent of physicians reported having an extensive, fully functional electronic-records system, and 13% reported having a basic system. In multivariate analyses, primary care physicians and those practicing in large groups, in hospitals or medical centers, and in the western region of the United States were more likely to use electronic health records. Physicians reported positive effects of these systems on several dimensions of quality of care and high levels of satisfaction. Financial barriers were viewed as having the greatest effect on decisions about the adoption of electronic health records.

CONCLUSIONS

Physicians who use electronic health records believe such systems improve the quality of care and are generally satisfied with the systems. However, as of early 2008, electronic systems had been adopted by only a small minority of U.S. physicians, who may differ from later adopters of these systems.

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HEALTH-INFORMATION TECHNOLOGY, such as sophisticated electronic health records, has the potential to improve health care.¹⁻³ Nevertheless, electronic-records systems have been slow to become part of the practices of physicians in the United States.^{4,5} To date, there have been no definitive national studies that provide reliable estimates of the adoption of electronic health records by U.S. physicians. Recent estimates of such adoption by physicians range from 9 to 29%.^{4,5} These percentages were derived from studies that either had a small number of respondents or incompletely specified definitions of an electronic health record.^{5,6}

To provide clearer estimates of the adoption of electronic-records systems by U.S. physicians, the Office of the National Coordinator for Health Information Technology of the Department of Health and Human Services⁴ supported our project to develop and test measures of adoption and to deploy those measures in a representative national survey of U.S. physicians. The goal was both to gather accurate information on current levels of adoption and to provide survey items that could be used to generate similar data over time on the diffusion of electronic health records and on physicians' perceptions of the effect of such systems on their practices.

This report addresses the following questions: What proportion of physicians report that outpatient electronic health records are available to them in office practice? How satisfied are physicians who use such systems, and what effect, if any, do they believe these systems have on the quality of care they provide to their patients?

METHODS

SURVEY DEVELOPMENT

The survey was developed by the investigators, with guidance from a consensus panel of experts in the fields of survey research, health-information technology, and health care management and policy and from representatives of hospital and physician groups and organizations. The development of the survey was also informed by focus groups and interviews with physicians and chief information officers and by a systematic review of previous surveys that were focused on the adoption of electronic health records.⁴

The survey was approved by the institutional

review board at Massachusetts General Hospital and by the federal Office of Management and Budget. The investigators drafted the manuscript and had complete independence in developing the survey, collecting and analyzing the data, and reporting the results.

DEVELOPING A MEASURE OF ADOPTION

On the basis of advice from the expert panel, the investigators defined the key functions that constitute an outpatient electronic health record and asked respondents to describe the availability and use of those functions. The investigators began with the Institute of Medicine's framework that defines possible functions of an electronic health record.⁷ Using a modified Delphi process, the panel reached consensus on functions that should be present to qualify the system as a "fully functional" electronic health record.² These functions generally fall into four domains: recording patients' clinical and demographic data, viewing and managing results of laboratory tests and imaging, managing order entry (including electronic prescriptions), and supporting clinical decisions (including warnings about drug interactions or contraindications). Physicians were asked whether their main practice site had a computerized system for each function (Table 1).

Recognizing that relatively few physicians might have fully functional electronic health records and that less complete electronic records might nevertheless convey benefits for patients' care, the investigators defined a minimum set of functions that would merit the use of the term "electronic health record," calling this a "basic" system (Table 1). The principal differences between a fully functional system and a basic system were the absence of certain order-entry capabilities and clinical-decision support in a basic system. The survey assessed physicians' access to various functions and whether the functions were used. However, since the overwhelming majority of physicians said they used most available functions, we primarily report findings on the availability of electronic health records in the office setting.

SURVEY SAMPLE

We identified all U.S. physicians who provide direct patient care from the 2007 Physician Masterfile of the American Medical Association (AMA).

Table 1. Survey Items Defining the Use of Electronic Health Records.

Survey Response	Basic System	Fully Functional System
Does your main practice site have a computerized system for any of the following?		
Health information and data		
Patient demographics	X	X
Patient problem lists	X	X
Electronic lists of medications taken by patients	X	X
Clinical notes	X	X
Notes including medical history and follow-up		X
Order-entry management		
Orders for prescriptions	X	X
Orders for laboratory tests		X
Orders for radiology tests		X
Prescriptions sent electronically		X
Orders sent electronically		X
Results management		
Viewing laboratory results	X	X
Viewing imaging results	X	X
Electronic images returned		X
Clinical-decision support		
Warnings of drug interactions or contraindications provided		X
Out-of-range test levels highlighted		X
Reminders regarding guideline-based interventions or screening		X

We excluded all doctors of osteopathy, residents, physicians working in federally owned hospitals, those with no listed address, those who requested not to be contacted, and those who were retired. From the resulting list, we randomly selected 5000 physicians for inclusion in the sample.

Of these 5000 physicians, 516 were ineligible to participate in the survey because they were deceased, retired, out of the country, practicing in a specialty that was not included in the survey (i.e., radiology, anesthesiology, pathology, or psychiatry), had no known address, or were not providing care to patients. Of the 4484 eligible respondents, 2758 completed the survey, which yielded a response rate of 62%. A copy of the survey appears in the Supplementary Appendix, available with the full text of this article at www.nejm.org.

SURVEY ADMINISTRATION

RTI International administered the survey between September 2007 and March 2008. Physicians received an initial mailing that included a cover letter, the survey, a postage-paid return envelope, and a check for \$20. Nonrespondents received reminders by mail and telephone. In January 2008, nonrespondents received another reminder and a \$40 check to encourage participation.

STATISTICAL ANALYSIS

All statistical analyses were conducted by researchers at Massachusetts General Hospital. We compared the characteristics of respondents with those in the AMA Masterfile using two-tailed chi-square tests with the use of SAS software, version 9.0 (Table 2).⁸ The respondents were more likely to be male than would be expected on the basis of national statistics. We adjusted for possible nonresponse bias as a result of this difference by creating a weight equal to the inverse of the response probability for men and women and used this weight in all the multivariate analyses.

We examined the univariate and bivariate relationships in the data. On the basis of these analyses, we applied a cumulative logit model, using SUDAAN, version 9.0.1 (RTI International),⁹ to evaluate the association between the characteristics of physicians (sex, race and ethnic background, number of years in practice, and medical specialty) and their practices (practice size, practice setting, location, and region of the country) with the availability of electronic health records, which was treated as an ordinal variable. From this model, we obtained percentages¹⁰ and the accompanying standard errors of availability of electronic health records, with adjustment for the characteristics mentioned above.

Second, we performed logistic-regression analysis to assess whether the availability of electronic health records was associated with a report by respondents that an electronic-records system had a positive effect on certain aspects of their practice. The third analysis assessed whether physicians were satisfied with their electronic records. The fourth analysis examined the barriers to and facilitators of adoption. These analyses were restricted to physicians who reported having access to a basic system or a fully functional system; the analyses were adjusted for significant characteristics of physicians and their practices.

Table 2. Characteristics of Survey Respondents and Their Practices.*

Characteristic	Respondents (N=2607)	AMA Characteristics (N=494,742) <i>no. (%)</i>	P Value
Physician			
Sex			
Male	1963 (75)	355,747 (72)	<0.001
Female	642 (25)	138,492 (28)	
Missing data	2 (<1)	503 (<1)	
Race or ethnic group†			
Hispanic or Latino			
Yes	124 (5)	NA	0.33
No	2332 (89)	NA	
Missing data	151 (6)	NA	
White	2014 (77)	NA	
Black	95 (4)	NA	
Asian	385 (15)	NA	
Other	35 (1)	NA	
Physician specialty			
Primary care	1231 (47)	238,315 (48)	0.33
Not primary care	1376 (53)	256,427 (52)	
Practice			
No. of years since graduation			
1–9	300 (12)	50,407 (10)	<0.09
10–19	772 (30)	147,032 (30)	
20–29	780 (30)	146,385 (30)	
≥30	755 (29)	150,917 (31)	
Missing data	0	1 (<1)	
No. of physicians in practice			
1–3	1155 (44)	NA	NA
4–5	456 (17)	NA	
6–10	444 (17)	NA	
11–50	342 (13)	NA	
>50	105 (4)	NA	
Missing data	105 (4)	NA	
Clinical setting			
Hospital or medical center	834 (32)	NA	NA
Office not attached to a hospital or medical center	1639 (63)	NA	
Other	81 (3)	NA	
Missing data	53 (2)	NA	
Location			
Urban	2158 (83)	NA	NA
Rural	449 (17)	NA	
Region			
Northeast	508 (19)	NA	NA
Midwest	602 (23)	NA	
South	895 (34)	NA	
West	602 (23)	NA	

* The characteristics of respondents were compared with those in the 2007 Physician Masterfile of the American Medical Association (AMA) with the use of two-tailed chi-square tests. The total number of respondents does not include 151 who provided incomplete responses. Percentages may not total 100 because of rounding. NA denotes not available.

† Respondents could select more than one race or ethnic group.

RESULTS

SURVEY RESPONDENTS

Four percent of respondents reported having a fully functional electronic-records system, and 13% reported having a basic system. Of the small number of respondents who had a fully functional system, 71% reported that their system was integrated with the electronic system at the hospital where they admit patients, as compared with only 56% of respondents with a basic system ($P=0.006$).

Among the 83% of respondents who did not have electronic health records, 16% reported that their practice had purchased but not yet implemented such a system at the time of the survey. An additional 26% of respondents said that their practice intended to purchase an electronic-records system within the next 2 years.

FACTORS ASSOCIATED WITH AVAILABILITY

In multivariate analyses, having an electronic-records system was significantly associated with several characteristics of both individual physicians and their practices (Table 3). Electronic-records systems were more prevalent among physicians who were younger, worked in large or primary care practices, worked in hospitals or medical centers, and lived in the western region of the United States. Rates of adoption did not differ significantly among providers serving a high proportion of minority patients or patients who were uninsured or receiving Medicaid, as compared with other physicians (data not shown).

FREQUENCY OF USE

Among the 4% of doctors with a fully functional electronic-records system, 97% reported using all the functions at least some of the time. Among the 13% of doctors with a basic system, more than 99% reported using all the functions at least some of the time.

OTHER CAPABILITIES

Physicians with electronic health records were asked to report the extent to which these systems allowed patients to do each of the following online: view and make changes to their medical records and request prescription refills, appointments, and referrals. Physicians with fully functional electronic-records systems were significantly more likely than those with basic systems to have each of these functions (Table 4). Enabling

patients to request a prescription refill online was a prevalent function for both basic systems and fully functional systems.

EFFECT ON PRACTICES

Figure 1 shows the percentages of respondents reporting positive effects of electronic health records on various aspects of their practices. Among the small number of respondents who had fully functional electronic-records systems, most physicians reported the positive effects of the system on the quality of clinical decisions (82%), communication with other providers (92%) and patients (72%), prescription refills (95%), timely access to medical records (97%), and avoidance of medication errors (86%). Furthermore, 82 to 85% reported a positive effect on the delivery of long-term and preventive care that meets guidelines. For physicians with basic systems, the magnitudes of effects were generally smaller. Results were adjusted for the characteristics of physicians and their practices.

Respondents also reported on whether the use of electronic health records had assisted in the care of patients in several specific ways (Table 4). Most of those with fully functional systems reported averting a known drug allergic reaction (80%) or a potentially dangerous drug interaction (71%), being alerted to a critical laboratory value (90%), ordering a critical laboratory test (68%), and providing preventive care (69%). Physicians with basic electronic-records systems reported having the same effects but less commonly than did those with fully functional systems.

PHYSICIAN SATISFACTION

A large majority of physicians reported being satisfied with their electronic-records systems overall (93% for fully functional systems and 88% for basic systems, $P=0.20$) and with the ease of use of the system when providing care to patients (88% and 81%, respectively; $P=0.11$). Physicians with fully functional electronic-records systems were significantly more likely to be satisfied with the reliability of their system than were those with basic systems (90% and 79%, respectively; $P=0.01$). Here again, results were adjusted for the characteristics of physicians and their practices.

BARRIERS TO ADOPTION

Among physicians who did not have access to an electronic-records system, the most commonly cited barriers to adoption were capital costs

Table 3. Rates of Adoption of Electronic Health Records by Physicians, with Adjustment for the Characteristics of the Physicians and Their Practices.*

Variable	Fully Functional System (N=117)	Standard Error	Basic System (N=330)	Standard Error	No Basic or Fully Functional System (N=2160)	Standard Error	P Value
	<i>percent</i>						
All physicians	4	1	13	1	83	<1	
Sex							0.76
Male	4	1	13	1	83	1	
Female	4	1	13	1	83	2	
Race or ethnic group†							0.99
Hispanic or Latino	4	1	13	2	83	3	
White	4	1	13	1	82	1	0.84
Black	5	2	14	4	80	6	0.72
Asian	5	2	14	3	82	5	0.82
Other	3	2	10	4	87	6	0.45
Medical specialty							<0.001
Primary care	6	1	15	1	80	1	
Not primary care	4	<1	11	1	86	1	
No. of years in practice							0.009
1–9	5	1	15	2	80	2	
10–19	5	1	14	1	81	1	
20–29	5	1	14	1	82	1	
≥30	3	1	10	1	87	1	
No. of physicians in practice							<0.001
1–3	2	<1	7	1	91	1	
4–5	3	1	11	1	86	2	
6–10	6	1	17	2	77	2	
11–50	8	1	22	2	71	3	
>50	17	3	33	3	50	5	
Clinical setting							0.008
Hospital or medical center	5	1	15	1	80	1	
Office not attached to a hospital or medical center	4	<1	12	1	85	1	
Other	4	1	13	3	83	4	
Location							0.92
Urban	4	<1	13	1	83	1	
Rural	4	1	13	1	83	2	
Region							0.002
Northeast	4	1	11	1	86	2	
Midwest	4	1	13	1	83	2	
South	4	1	12	1	84	1	
West	6	1	16	1	78	2	

* Percentages were calculated with the use of multivariable analysis, applying a cumulative logit model to predict the adoption of an electronic-records system, with adjustment for all variables listed in the table. The analysis was adjusted for nonresponse. The total number of respondents does not include 151 who provided incomplete responses. Percentages (which sum across rows) may not total 100 because of rounding.

† Respondents could select more than one race or ethnic group.

Table 4. Rates of Response Regarding Functions of Electronic Health Records and Their Effects.*

Survey Response	Fully Functional System	Basic System	P Value
	<i>percent</i>		
Does your system allow patients to do the following?			
View their medical records online	50	24	<0.001
Make changes to or update their medical records online	26	15	0.01
Request appointments online	52	26	<0.001
Request referrals online	36	14	<0.001
Request refills for prescriptions online	63	26	<0.001
Has a prompt from the electronic-records system ever helped you do the following?			
Prevent a drug allergy	80	66	0.01
Prevent a potentially dangerous medication interaction	71	54	0.002
Be alerted to a critical laboratory value	90	75	0.004
Provide preventive care	69	41	<0.001
Order a critical laboratory test	68	36	<0.001
Order a genetic test	17	8	0.03

* Percentages were calculated with the use of a multivariable logistic-regression model. Variables included in the model were medical specialty (primary care vs. not primary care), the number of years since graduation (1 to 9, 10 to 19, 20 to 29, or ≥ 30), the number of physicians in the practice (1 to 3, 4 to 5, 6 to 10, 11 to 50, or >50), clinical setting (hospital, private office, or other), and region (Northeast, Midwest, South, or West). Separate models were fitted for each of these questions.

(66%), not finding a system that met their needs (54%), uncertainty about their return on the investment (50%), and concern that a system would become obsolete (44%) (Table 5). Physicians with electronic health records tended to highlight the same barriers but less frequently than did non-adopters.

FACILITATORS OF ADOPTION

Among all respondents, the factors that were most frequently cited as facilitators of adoption were financial incentives for the purchase (55% among physicians with no electronic health records and 46% among those with electronic health records, $P=0.001$) and payment for use of an electronic-records system (57% and 52%, respectively; $P=0.04$). About 40% of respondents with and without an electronic-records system also reported that protecting physicians from personal liability for record tampering by external parties could be a major facilitator of adoption.

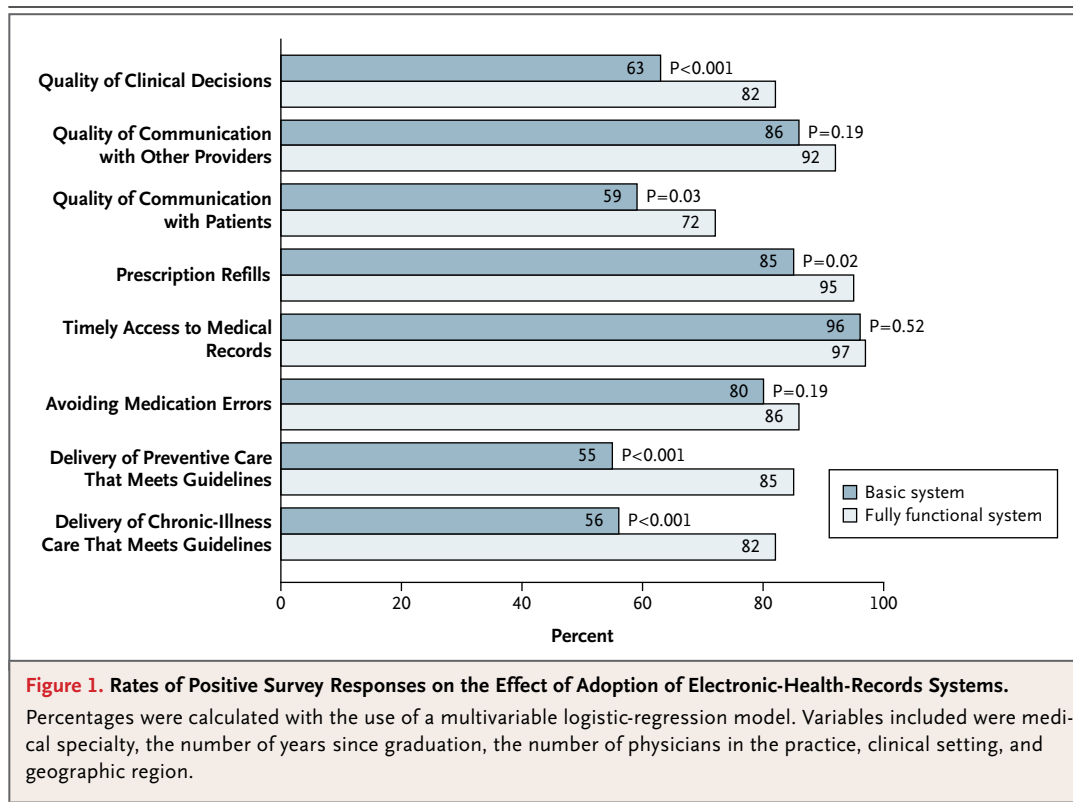
DISCUSSION

On the basis of a large, representative sample of U.S. physicians and clearly specified, replicable

definitions of electronic-records systems that were developed by a panel of experts, our study indicates that electronic health records are available in the office setting to only a small minority (17%) of U.S. physicians at present. Only 4% of physicians have what the expert panel considered a fully functional electronic-records system.

Previous studies have shown that the practice setting (and especially the size of the group) had a significant influence on the adoption of electronic health records in the United States, findings that our results confirm.^{5,6,11} After adjustment for other characteristics of physicians and their practices, we found that physicians who practice in groups of more than 50 were three times as likely to have a basic electronic-records system and more than four times as likely to have a fully functional electronic-records system as were physicians in groups of 3 or fewer. However, even in large groups, only a small minority (17%) had a fully functional system, and 49% had no electronic-records system at all.

Subjective reports by respondents about the influence of electronic health records on the quality of their practice and clinical decisions and about their satisfaction with the system are



encouraging. The proportion of respondents reporting positive effects was generally larger for fully functional systems than for basic systems, a finding that is consistent with the hypothesis that more capable systems offer greater benefits. However, the possibility of bias among respondents, especially greater receptivity to and facility with electronic health records among early adopters, cannot be excluded. The quality and cost effects of electronic health records need to be confirmed by direct studies of clinical outcomes. Considerable controversy continues about the overall effect of electronic health records, and further research needs to clarify the effects of this technology on our health care system.¹

It is also encouraging that a large majority of respondents reported overall satisfaction with their electronic-records system. However, approximately 20% of physicians with basic systems expressed reservations about the ease of use and reliability of their systems. Improving the usability of electronic health records may be critical to the continued successful diffusion of the technology.

Even though we used definitions and methods that differed from those used in previous studies

of electronic-records systems, it is possible, within limits, to compare our findings with those of other studies. For example, in 2006, the National Ambulatory Medical Care Survey (NAMCS) showed that 9.3% of respondents had adopted systems similar to (though not exactly the same as) our current definition of a basic electronic record.² Applying the NAMCS definition, we found that 14% of our respondents reported having an electronic-records system. This finding suggests that the number of physicians with some type of electronic-records system has increased in the past year. The function-based approach that we used to measure the availability and use of electronic health records will enable future researchers to gauge progress in the adoption of such systems on the basis of alternative definitions, including that used by NAMCS.

Our study and others¹⁻³ serve to underscore both the potential benefits of electronic health records and the low current availability of this technology. The combination of these findings suggests that the U.S. health care system faces major challenges in taking full advantage of electronic health records to realize its health care goals. President Bush has proposed that elec-

Table 5. Barriers to the Adoption of Electronic Health Records.*			
Variable	Any Electronic-Records System†	No Electronic-Records System	P Value
	<i>percent</i>		
Amount of capital needed			
Major barrier	47	66	<0.001
Minor barrier	30	22	
Uncertainty about return on investment			
Major barrier	33	50	<0.001
Minor barrier	34	31	
Resistance from physicians			
Major barrier	27	29	0.37
Minor barrier	42	42	
Capacity to select, contract, install, and implement			
Major barrier	26	39	<0.001
Minor barrier	45	42	
Concern about loss of productivity during transition			
Major barrier	35	41	0.02
Minor barrier	42	40	
Concern about inappropriate disclosure of patient information			
Major barrier	14	17	0.09
Minor barrier	43	45	
Concern about illegal record tampering			
Major barrier	14	18	0.007
Minor barrier	42	46	
Concern about the legality of accepting electronic records from hospital			
Major barrier	7	11	0.001
Minor barrier	27	33	
Concern about physicians' legal liability			
Major barrier	11	14	0.02
Minor barrier	34	38	
Finding an electronic-records system to meet needs			
Major barrier	38	54	<0.001
Minor barrier	38	32	
Concern that system will become obsolete			
Major barrier	27	44	<0.001
Minor barrier	44	40	

* Percentages were calculated with the use of a multivariable logistic-regression model. Variables included in the model were medical specialty (primary care vs. not primary care), the number of years since graduation (1 to 9, 10 to 19, 20 to 29, or ≥30), the number of physicians in the practice (1 to 3, 4 to 5, 6 to 10, 11 to 50, or >50), clinical setting (hospital, private office, or other), and region (Northeast, Midwest, South, or West). Separate models were fitted for each of these questions.

† The category includes both fully functional and basic electronic health records.

tronic health records should be widespread in the U.S. health care system by 2014, and both of the likely presidential candidates have prominently featured the diffusion of electronic health records in their health care proposals.¹²⁻¹⁴ Indeed, recent Medicare cost-containment proposals included incentives for the adoption of health-information technology by physicians as a means of spurring greater use.¹⁵ Our data suggest that such incentives could be important facilitators of adoption. However, the cost of achieving widespread adoption of electronic health records in the United States could be high, probably in the tens or hundreds of billions of dollars,^{1,16-19} and whether any future federal administration will find the necessary resources is uncertain.

In their efforts to spur adoption of electronic health records, policymakers may benefit from studying the experience of other Western countries, which seem to have been much more successful (despite significantly lower overall national health expenditures) at encouraging the adoption of health-information technology by physicians. Data from 10 Western industrialized nations suggest that a large majority (often more than 90%) of primary care physicians currently use computers in their office practices.²⁰ These countries seem to have achieved these results using a variety of interventions — public and private, economic and noneconomic — that may offer guidance to future actions in the United States.²⁰

Certain limitations of our study should be taken into account. Like all surveys, ours was subject to potential problems of response bias. It is possible that physicians who responded to our survey had a greater interest than did nonresponders in the subject of electronic health rec-

ords. Although we adjusted for potential nonresponse bias, our data may overestimate actual rates of adoption of electronic health records. Another reason to be cautious about the reports is that the estimates of the effect of these systems on quality of care and satisfaction are based on a small number of respondents with a large margin of error, especially for the fully functional electronic-records systems. As already noted, by virtue of having electronic health records at this stage in their diffusion, the respondents with these systems are probably different from respondents without them. This limitation, coupled with the small number of adopters in our study, suggests that any extrapolation of the benefits and satisfaction with electronic health records reported by respondents should be done with caution.

In discussions about health-information technology, our study informs the debate by providing benchmark information about the levels of adoption of electronic health records by U.S. physicians as of late 2007 and early 2008. Further studies that use clear, similar definitions of electronic health records and representative samples of physicians will be necessary to inform the development of policies with regard to electronic health records in our health care system.

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