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

Catherine M. DesRoches, Dr.P.H., Eric G. Campbell, Ph.D., Sowmya R. Rao, Ph.D., Karen Donelan, Sc.D., Timothy G. Ferris, M.D., M.P.H., Ashish Jha, M.D., M.P.H., Rainu Kaushal, M.D., M.P.H., Douglas E. Levy, Ph.D., Sara Rosenbaum, J.D., Alexandra E. Shields, Ph.D., and David Blumenthal, M.D., M.P.P.

ABSTRACT

From the Institute for Health Policy (C.M.D., E.G.C., S.R.R., K.D., D.E.L., A.E.S., D.B.) and the Massachusetts General Physicians Organization (T.G.F.), Massachusetts General Hospital; and Harvard Medical School (A.J.) — both in Boston; Weill Cornell Medical College, New York (R.K.); and the Department of Health Policy, George Washington University, Washington, DC (S.R.). Address reprint requests to Dr. DesRoches at the Institute for Health Policy, Massachusetts General Hospital, Suite 900, 50 Staniford St., Boston, MA 02114, or at cdesroches@partners.org.

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.

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 Services[4] 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 contra-indications 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 percentages[10] 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)	P Value
	no. (%)		
Physician			
Sex			<0.001
Male	1963 (75)	355,747 (72)	
Female	642 (25)	138,492 (28)	
Missing data	2 (<1)	503 (<1)	
Race or ethnic group†			
Hispanic or Latino			
Yes	124 (5)	NA	
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			0.33
Primary care	1231 (47)	238,315 (48)	
Not primary care	1376 (53)	256,427 (52)	
Practice			
No. of years since graduation			<0.09
1–9	300 (12)	50,407 (10)	
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	
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	
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	
Rural	449 (17)	NA	
Region			
Northeast	508 (19)	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
			percent				
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
	percent		
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 nonadopters.

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

Figure 1. Rates of Positive Survey Responses on the Effect of Adoption of Electronic-Health-Records Systems.

Percentages were calculated with the use of a multivariable logistic-regression model. Variables included were medical specialty, the number of years since graduation, the number of physicians in the practice, clinical setting, and geographic region.
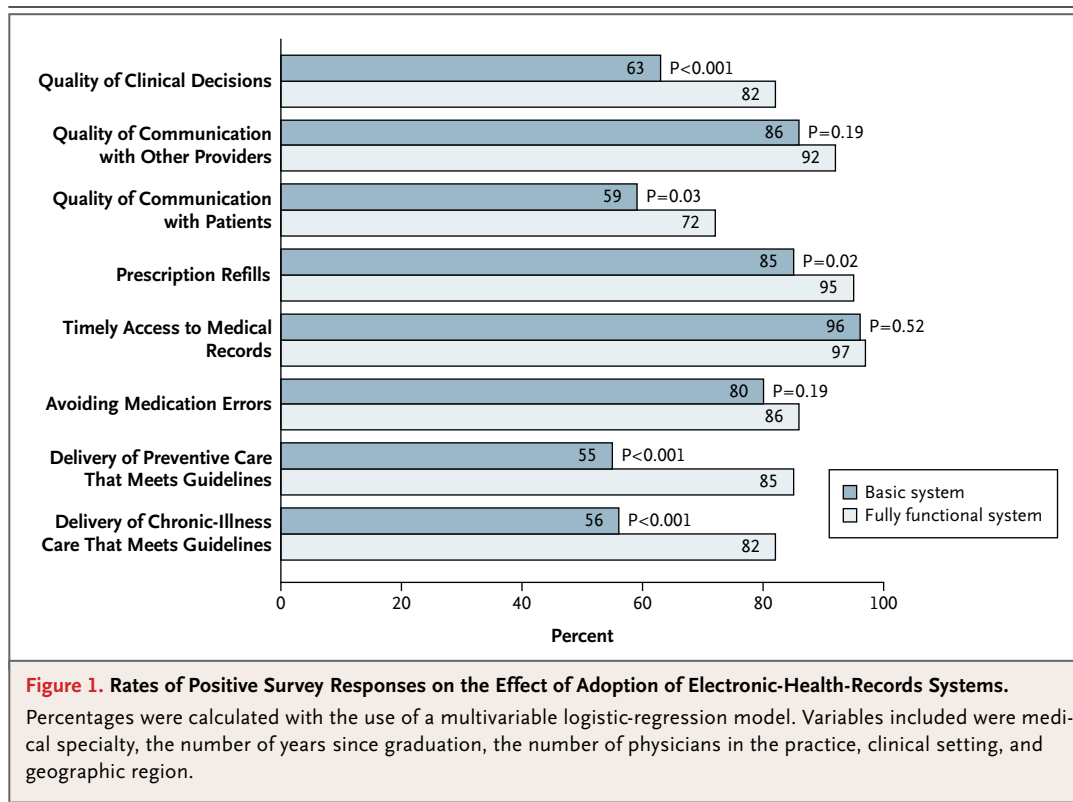
encouraging. The proportion of respondents reporting positive effects was generally larger for fully functional systems than for basic systems, a finding that is consistent with the hypothesis that more capable systems offer greater benefits. However, the possibility of bias among respondents, especially 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 others[1-3] 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
	percent		
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.

REFERENCES

1. Shekelle PG, Morton SC, Keeler EB. Costs and benefits of health information technology. Evid Rep Technol Assess (Full Rep) 2006;132:1-71.
2. Blumenthal D, DesRoches C, Donelan K, et al. Health information technology in the United States: the information base for progress. Princeton, NJ: Robert Wood Johnson Foundation, 2006.
3. 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;144:742-52.
4. Jha AK, Ferris TG, Donelan K, et al. How common are electronic health records in the United States? A summary of the evidence. Health Aff (Millwood) 2006; 25:w496-w507.
5. Hing ES, Burt CW, Woodwell DA. Electronic medical record use by office-based physicians and their practices: United States, 2006. Advanced data from vital and health statistics (DHHS publication no. (PHS) 2008-1250). No. 393. Hyattsville, MD: National Center for Health Statistics, October 26, 2007:1-7.
6. Schoen C, Osborn R, Huynh PT, Doty M, Peugh J, Zapert K. On the front lines of care: primary care doctors' office systems, experiences, and views in seven countries. Health Aff (Millwood) 2006;25: w555-w571.
7. ISO/TC. Electronic health record definition, scope, and context (2nd draft). ISO/TC 215 technical report. Geneva: International Organization for Standardization, August 2003.
8. SAS OnlineDoc 9.1.3. Cary, NC: SAS Institute, 2002-2005. (Accessed June 10, 2008, at http://support.sas.com/onlinedoc/913/docMainpage.jsp.)
9. SUDAAN language manual, release 9.0. Research Triangle Park, NC: Research Triangle Institute, 2004.
10. Korn EL, Graubard BI. Analysis of health surveys. New York: John Wiley, 1999.
11. Bates DW. Physicians and ambulatory electronic health records. Health Aff (Millwood) 2005;24:1180-9.

12. Presidential candidate Barack Obama's Web site. (Accessed June 10, 2008, at http://www.barackobama.com/index.php.)

13. Presidential candidate John McCain's Web site. (Accessed June 10, 2008, at http://www.johnmccain.com.)

14. The Henry J. Kaiser Family Foundation. 2008 Presidential candidate health care proposals: side-by-side summary. (Accessed June 10, 2008, at http://www.health08.org/sidebyside_results.cfm?c=5&c=11&c=16.)

15. Armstrong D. Bush administration sends medicare legislation to Congress. Congressional Quarterly. February 15, 2008.

16. Kaushal R, Jha AK, Franz C, et al. Return on investment for a computerized physician order entry system. J Am Med Inform Assoc 2006;13:261-6.

17. Miller RH, West C, Brown TM, Sim I, Ganchoff C. The value of electronic health records in solo or small group practices. Health Aff (Millwood) 2005;24:1127-37.

18. Miller RH, West CE. The value of electronic health records in community health centers: policy implications. Health Aff (Millwood) 2007;26:206-14.

19. Hillestad R, Bigelow J, Bower A, et al. Can electronic medical record systems transform health care? Potential health benefits, savings, and costs. Health Aff (Millwood) 2005;24:1103-17.

20. Protti D. A comparison of information technology in general practice in ten countries. Healthc Q 2007;10:107-16.

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Supplementary Appendix

This appendix has been provided by the authors to give readers additional information about their work.

Summary protocol

Research Design and Methods:

The physician survey was developed by the study team. Along with Research Triangle Institute (RTI), the study team submitted the survey instrument for the Office of Management and Budget (OMB) approval through the U.S. Department of Health and Human Services. Following response to OMB revisions, the study team conducted 10 cognitive interviews with physicians in order to refine the survey items. The survey was revised based on these interviews and pretested with 100 randomly selected respondents.

The study team fielded the survey in collaboration with RTI. The survey was mailed to respondents with a cover letter and instructions for completion and returning of the survey. Physicians were queried about the following: use of EHRs, plans for adoption, barriers to and incentives for adoption, individual components of the EHR system at their practice (including Computerized Physician Order Entry, decision support, etc), satisfaction with their system, and perceived benefits for patient care. The survey took 20 minutes. RTI was responsible for identifying the sample of physicians. The physicians survey was mailed to 5,000 subjects across the country. The survey sample was developed in order to create a representative national sample. Follow-up phone calls and letters were sent to non-respondents. The initial mailing included a $20 incentive to encourage participation. A subsequent mailing included a $40 check.

Before data analysis of each survey, RTI removed all individual identifiers from the survey data before sending it to the research partners at Partners/MGH, Partner/BWI, and George Washington University. Data analyses was done primarily at Partners/MGH with assistance from project team members at Partners/BWI and George Washington University.

Privacy and confidentiality:

The sample list (with respondent names and contact information) was available only to authorized personnel at RTI. RTI's Institutional Review Board approved the list project staff requiring access. Data was stored in a password protected network environment. To protect respondent confidentiality, RTI encrypted identifiable data that are stored on company-issued personal computers. All RTI staff with access to respondent information (including phone center staff and those who prepare documents for shipping) are required to sign confidentiality agreements. These agreements are enforced, and penalties for violation include termination of employment. As mailed data are being prepared for shipment or as they are returned, they will be stored in a secure environment, regardless of the form in which data are returned. Access to electronic data is controlled by password protection. Buildings are protected by a security force and locked entryways. Any ID number assigned to a respondent will be de-linked from personally identifying information at the end of data collection. Any files linking identifiable information and an ID will be stored in a secure environment. After data collection, electronic files with names and address information will be destroyed. No hard-copy forms of the list will be produced

A National Survey of Health Record Keeping among Physicians & Group Practices in the United States

000. Practice Characteristics

01. At how many different office locations do you see ambulatory patients?

    ❑$_1$ One
    ❑$_2$ Two
    ❑$_3$ Three or more
    ❑$_4$ None, I do not see any outpatients

> *If you practice at more than one location, please keep in mind your **main practice site** for the remaining questions.*
>
> *By "main practice site" we mean the location at which **you see the most ambulatory patients**.*

002. During a typical week, what percent of your patient visits are provided at your *main practice site*?

    ❑$_1$ Less than 25%
    ❑$_2$ 25%-49%
    ❑$_3$ 50% - 75%
    ❑$_4$ More than 75%

003. How many physicians are associated with you, at your main practice site? _____.

004. Is your main practice site a single-specialty practice, or a multi-specialty practice?

    ❑$_1$ Single specialty group or partnership
    ❑$_2$ Multi-specialty group or partnership

005. What is the primary setting of your main practice site?

- ❑₁   Hospital, medical-center.
- ❑₂   Ambulatory surgical center.
- ❑₃   Urgent-care facility.
- ❑₄   Laboratory or imaging center, outside a hospital.
- ❑₅   A physician office not attached to a hospital, or on a medical center campus.

006.   About what percentage of your patients in your main practice site:

	Less than 10%	10% to *less* than 25%	25% to *less* than 50%	50% or more
a. are uninsured (do <u>not</u> have health insurance coverage)?	❑₁	❑₂	❑₃	❑₄
b. are covered by <u>Medicaid</u> (including managed care)?	❑₁	❑₂	❑₃	❑₄
c. are African American or Black?	❑₁	❑₂	❑₃	❑₄
e. are Hispanic or Latino?	❑₁	❑₂	❑₃	❑₄
f. have a primary language <u>other than English</u>?	❑₁	❑₂	❑₃	❑₄

007. During your last full week of work, approximately how many patient visits did you personally have at your main practice site?

_____.

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100. Use of computers in your *main practice site*

101. Does your main practice site have a computerized system for any of the following? For those features, please indicate the extent to which they are available to **you** and the extent to which **you** use them. If a feature is unavailable, check "no" to availability and skip the related "use" question.

	Availability			Use			
	Yes	No	Don't Know	I do <u>not</u> use	I use *some* of the time	I use *most or all* of the time	Not applicable to my practice or specialty
a) Patient demographics	$\square_1$	$\square_2$	$\square_3$	$\square_1$	$\square_2$	$\square_3$	$\square_4$
b) Patient problem lists	$\square_1$	$\square_2$	$\square_3$	$\square_1$	$\square_2$	$\square_3$	$\square_4$
c) Orders for prescriptions?	$\square_1$	$\square_2$	$\square_3$	$\square_1$	$\square_2$	$\square_3$	$\square_4$
d) *If yes* – are there warnings of drug interactions or contraindications provided?	$\square_1$	$\square_2$	$\square_3$	$\square_1$	$\square_2$	$\square_3$	$\square_4$
e) *If* yes -- are prescriptions sent electronically to the pharmacy?	$\square_1$	$\square_2$	$\square_3$	$\square_1$	$\square_2$	$\square_3$	$\square_4$
f) Orders for laboratory tests?	$\square_1$	$\square_2$	$\square_3$	$\square_1$	$\square_2$	$\square_3$	$\square_4$
g) *If yes* – are orders sent electronically?	$\square_1$	$\square_2$	$\square_3$	$\square_1$	$\square_2$	$\square_3$	$\square_4$
h) Orders for radiology tests?	$\square_1$	$\square_2$	$\square_3$	$\square_1$	$\square_2$	$\square_3$	$\square_4$
i) *If* yes -- are orders sent electronically?	$\square_1$	$\square_2$	$\square_3$	$\square_1$	$\square_2$	$\square_3$	$\square_4$
j) Viewing Lab results?	$\square_1$	$\square_2$	$\square_3$	$\square_1$	$\square_2$	$\square_3$	$\square_4$
k) *If yes* – are out-of-range levels highlighted?	$\square_1$	$\square_2$	$\square_3$	$\square_1$	$\square_2$	$\square_3$	$\square_4$
l) Viewing Imaging results?	$\square_1$	$\square_2$	$\square_3$	$\square_1$	$\square_2$	$\square_3$	$\square_4$
m) *If yes* – are electronic images returned?	$\square_1$	$\square_2$	$\square_3$	$\square_1$	$\square_2$	$\square_3$	$\square_4$
n) Clinical notes?	$\square_1$	$\square_2$	$\square_3$	$\square_1$	$\square_2$	$\square_3$	$\square_4$
o) *If yes* – do they include medical history and follow up notes?	$\square_1$	$\square_2$	$\square_3$	$\square_1$	$\square_2$	$\square_3$	$\square_4$
p) Electronic lists of what medications each patient takes?	$\square_1$	$\square_2$	$\square_3$	$\square_1$	$\square_2$	$\square_3$	$\square_4$
q) Reminders for guideline-based interventions and/or screening tests?	$\square_1$	$\square_2$	$\square_3$	$\square_1$	$\square_2$	$\square_3$	$\square_4$
r) Public health reporting?	$\square_1$	$\square_2$	$\square_3$	$\square_1$	$\square_2$	$\square_3$	$\square_4$
s) *If yes*—are notifiable diseases sent electronically?	$\square_1$	$\square_2$	$\square_3$	$\square_1$	$\square_2$	$\square_3$	$\square_4$

200. Acquisition and Implementation of an EHR system

201. Does your *main* practice use an electronic health record (not including billing records)?

- $\square_1$ Yes, all electronic
- $\square_2$ Yes, part paper, part electronic
- $\square_3$ No
- $\square_4$ Don't know

202. As of today, what is your degree of electronic health record acquisition or implementation at your main practice site [Choose one]

    ❑₁ We have acquired an EHR system, but have not implemented it (go to Question 203).
    ❑₂ Our EHR implementation is in process (go to Question 203)
    ❑₃ We have fully implemented our EHR system (go to Section 300)
    ❑₄ We plan to acquire an EHR system in the next 12 months (go to Section 400)
    ❑₅ We plan to acquire an EHR system in the next 13 – 24 months (go to Section 400)
    ❑₆ We have no plans to acquire an EHR system (go to Section 400).

    203. If you have purchased and are in the process of implementing an EHR system, when do you expect to have completed implementation?

        ❑₁ in the next 12 months.
        ❑₂ in the next 13 to 24 months.

> **IF YOUR MAIN PRACTICE SITE USES PAPER RECORDS PLEASE GO TO SECTION 400.**
>
> **IF YOUR SITE USES ELECTRONIC HEALTH RECORDS OR IS IN TRANSITION TO AN EHR SYSTEM PLEASE COMPLETE THE FOLLOWING SECTION.**

300. Experience with Electronic Health Records

301. How many years have you been using an EHR in your main practice site? _____ years.

302. To what extent has the EHR system affected the following areas at your main practice site?

	Major positive impact	Positive impact	No impact	Negative impact	Major negative impact	Not applicable
a) The quality of clinical decisions	❑₁	❑₂	❑₃	❑₄	❑₅	❑₆
b) Communication with other providers	❑₁	❑₂	❑₃	❑₄	❑₅	❑₆
c) Communication with your patients	❑₁	❑₂	❑₃	❑₄	❑₅	❑₆
d) Prescription refills	❑₁	❑₂	❑₃	❑₄	❑₅	❑₆
e) Timely access to medical records	❑₁	❑₂	❑₃	❑₄	❑₅	❑₆
g) Avoiding medication errors	❑₁	❑₂	❑₃	❑₄	❑₅	❑₆
f) Delivery of preventive care that meets guidelines	❑₁	❑₂	❑₃	❑₄	❑₅	❑₆
g) Delivery of chronic illness care that meets guidelines	❑₁	❑₂	❑₃	❑₄	❑₅	❑₆

303. In providing patient care since adopting an EHR system at your main practice site, have you

	Yes		No	Not applicable
	In the last 6 months	**Ever**		
a) Avoided a drug allergy because of an EHR?	$\square_1$	$\square_2$	$\square_3$	$\square_4$
b) Avoided a potentially dangerous medication interaction because of an EHR?	$\square_1$	$\square_2$	$\square_3$	$\square_4$
c) Been alerted to a critical lab value by an EHR?	$\square_1$	$\square_2$	$\square_3$	$\square_4$
d) Provided preventive care (e.g., vaccine, colonoscopy, mammogram) because you were prompted by an EHR?	$\square_1$	$\square_2$	$\square_3$	$\square_4$
e) Ordered a critical lab test (such as HbA1c or LDL) as a result of an electronic prompt from an EHR?	$\square_1$	$\square_2$	$\square_3$	$\square_4$
f) Ordered a genetic test as a result of a prompt from an EHR?	$\square_1$	$\square_2$	$\square_3$	$\square_4$

304. Overall, how satisfied are you with the EHR system at your main practice?

Very satisfied	**Somewhat satisfied**	**Somewhat dissatisfied**	**Very dissatisfied**
$\square_1$	$\square_2$	$\square_3$	$\square_4$

305. How satisfied are you with each of the following aspects of your EHR system?

	Very satisfied	**Somewhat satisfied**	**Somewhat dissatisfied**	**Very dissatisfied**
a) Ease of use when providing direct care to a patient	$\square_1$	$\square_2$	$\square_3$	$\square_4$
b) Reliability of the system (i.e. frequency of system failures, system speed)	$\square_1$	$\square_2$	$\square_3$	$\square_4$
c) Sharing of medical information with hospitals and other health-care providers	$\square_1$	$\square_2$	$\square_3$	$\square_4$

306. Please indicate whether the EHR system at your *main practice site* allows patients to…

	Yes	**No**	**Don't know**
a. View their medical record online	$\square_1$	$\square_2$	$\square_3$
b. Make changes to or update their medical record online	$\square_1$	$\square_2$	$\square_3$
c. Request appointments online	$\square_1$	$\square_2$	$\square_3$
d. Request referrals online	$\square_1$	$\square_2$	$\square_3$
e. Request refills for prescriptions online	$\square_1$	$\square_2$	$\square_3$

307. Is the electronic health record system at your main practice site integrated with a hospital system where you admit patients (i.e. your patient's ambulatory EHR is accessible through the hospital's EHR system)?

Yes	No	Don't know
❏$_1$	❏$_2$	❏$_3$

308. If you use an electronic health record, does it meet certification standards?

Yes	No	Don't know
❏$_1$	❏$_2$	❏$_3$

400. Use of E-mail

401. Please indicate how frequently you communicate by e-mail with each of the following:

	Never	Rarely	Sometimes	Frequently
a) Patients about medical issues	❏$_1$	❏$_2$	❏$_3$	❏$_4$
b) Other physicians in your practice about patient care	❏$_1$	❏$_2$	❏$_3$	❏$_4$
c) Other staff in your practice about patient care	❏$_1$	❏$_2$	❏$_3$	❏$_4$
d) Other physicians who are not in your practice about patient issues	❏$_1$	❏$_2$	❏$_3$	❏$_4$

500. Barriers to EHR adoption

501. Please answer the next set of questions, **regardless of whether your main practice site has acquired an EHR system or has not.** If your practice site has acquired an EHR system, please tell us how much of a barrier each of the following was. If your practice has not acquired an EHR, please indicate how much of a barrier it is to adoption, even if you have no immediate plans to adopt.

	Major barrier	Minor barrier	Not a barrier
Financial Barriers			
a. The amount of capital needed to acquire and implement an EHR	❏$_1$	❏$_2$	❏$_3$
b. Uncertainty about the return on investment (ROI) from an EHR	❏$_1$	❏$_2$	❏$_3$
Organizational Barriers			
c. Resistance to adoption from practice physicians	❏$_1$	❏$_2$	❏$_3$
d. Capacity to select, contract, install and implement an EHR	❏$_1$	❏$_2$	❏$_3$
e. Concern about loss of productivity during transition to the EHR system	❏$_1$	❏$_2$	❏$_3$
Legal or Regulatory Barriers			
f. Concerns about inappropriate disclosure of patient information (i.e. breaches of patient confidentiality)	❏$_1$	❏$_2$	❏$_3$
g. Concerns about illegal record tampering or "hacking"	❏$_1$	❏$_2$	❏$_3$
h. Concerns about the legality of accepting an EHR that is donated from a hospital	❏$_1$	❏$_2$	❏$_3$
i. Concerns about physicians' legal liability if patients have more access to information in their medical records	❏$_1$	❏$_2$	❏$_3$
State of the Technology			
j. Finding an EHR system that meets providers' needs	❏$_1$	❏$_2$	❏$_3$
k. Concerns that the system will become obsolete	❏$_1$	❏$_2$	❏$_3$

600. Incentives for EHR adoption

601. Please rate the impact the following possible policy changes would have on your decision to adopt an EHR. If you have adopted an EHR, please rate the impact of the following possible policy changes on EHR adoption among physicians generally. Please indicate whether the impact was positive or negative.

	Major positive impact	Minor positive impact	No Impact	Minor negative impact	Major negative impact
Legal or Regulatory Incentives					
a. Change the law to protect physicians from personal liability for record tampering by external parties or for privacy and security breaches	$\Box_1$	$\Box_2$	$\Box_3$	$\Box_4$	$\Box_5$
b. Concerns about legal liability as a result of NOT using the latest technology	$\Box_1$	$\Box_2$	$\Box_3$	$\Box_4$	$\Box_5$
State of the Technology					
c. Published certification standards that indicate whether an EHR has the necessary capabilities and functions.	$\Box_1$	$\Box_2$	$\Box_3$	$\Box_4$	$\Box_5$
Financial Incentives					
d. Incentives for the purchase of an EHR (e.g. tax credits, low interest loans, grants)	$\Box_1$	$\Box_2$	$\Box_3$	$\Box_4$	$\Box_5$
e. Additional payment for the use of an EHR (i.e. additional reimbursement for using an EHR).	$\Box_1$	$\Box_2$	$\Box_3$	$\Box_4$	$\Box_5$

602. Has your practice purchased any of the following *in the last three years?*

	Yes	No	Don't know
New examining rooms	$\Box_1$	$\Box_2$	$\Box_3$
An x-ray or imaging machine	$\Box_1$	$\Box_2$	$\Box_3$
Acquired, or opened another practice site	$\Box_1$	$\Box_2$	$\Box_3$
Clinical laboratory equipment	$\Box_1$	$\Box_2$	$\Box_3$

900. Physician and practice characteristics

901.   What is the year of your birth?   19_____

902.   What is your gender?

$\Box_1$ Male $\Box_2$ Female

903.   What is your ethnicity?

$\Box_1$ Hispanic or Latino
$\Box_2$ Not Hispanic or Latino   **Please turn to the next page**.

904. What is your race? (check all that apply)

    ❑₁   White
    ❑₂   Black/African American
    ❑₃   Asian
    ❑₄   Native Hawaiian/Other Pacific Islander
    ❑₅   American Indian/Alaska Native

905. In what area are you board certified?

_____

906. Regardless of board certification, what do you consider your main specialty?

_____

907. In what year did you first practice medicine, after completing residency or fellowship?
_____.

908. Roughly, what percent of your patient care revenue comes from (note: percentage should total to 100%)?

____ ____Medicare
____ ____Medicaid
____ ____Private insurance
____ ____Patient payments
____ ____Other _____.

If you have an office manager or practice manager, please let us know how we can reach that person in case we have follow up questions (please print):

    Name: _____

    Title:_____

    Street address:_____

    City:_____, **State:**_____ ZIP_____

    Phone number: (_____)_____**ext.**_____

THANK YOU FOR COMPLETING THIS FORM.

PLEASE RETURN IT IN THE ENCLOSED ENVELOPE.

Technical Appendix

Physicians were asked about the impact of their EHR on each of the following: the quality of clinical decisions, quality of communication with patients, quality of communication with other providers, prescription refills, timely access to medical records, avoiding medication errors, delivery of preventive care that meets guidelines, and delivery of chronic care that meets guidelines. Response categories were: major positive impact, positive impact, no impact, negative impact, major negative impact, and not applicable. These were combined into two categories: positive impact and neutral/negative impact (this included no impact, negative impact, and major negative impact). Subjects who responded as 'not applicable' were excluded from the analysis.

To further assess the impact of EHRs on patient care, physicians with EHRs were asked to report whether they had done each of the following due to a prompt from their EHR: avoided a drug allergy, avoided a potentially dangerous medication interaction, been alerted to a critical lab value, provided preventive care, ordered a critical lab test, or ordered a genetic test. Response categories were "yes, ever", "yes, in the past 6 months", "no", and "not applicable". Physicians who responded "not applicable" were excluded from the analysis.

To assess the extent to which physicians' EHR systems allowed patients to interact with the system, the survey asked the following question: "does your EHR allow patients to do each of the following?" Survey items were: view medical records online, make changes or update their medical record online; request appointments online; request referrals online; request refills for prescriptions online. Physicians were instructed to answer "yes", "no", or "don't know" for each item.

To assess satisfaction with EHR systems, physicians were asked to rate their level of satisfaction with each of the following: the system overall, ease of use when providing patient care, reliability of the system, and sharing of medical information. The satisfaction variables had four response categories (very satisfied, somewhat satisfied, somewhat dissatisfied, and very dissatisfied). These were combined into two categories: satisfied and dissatisfied. Physicians who did not respond to any of the items were excluded from the analysis.

Physicians were asked to rate the impact of each of the following barriers on their decision to adopt an EHR: the amount of capital needed to purchase an EHR; uncertainty about the return on investment; resistance from physicians in the practice; uncertainty about their capacity to select, contract for, install, and implement a system; concerns about a loss of productivity during the implementation; concerns about inappropriate disclosure of patient information; concerns about illegal record tampering; concerns about the legality of accepting a donated EHR; concerns about physicians legal liability; finding and EHR that meets the providers needs; and concerns that the system will become obsolete. The barrier variables had three response categories (major barrier, minor barrier, and not a barrier). We included all of the categories in the logit model, however we do not show the "not a barrier" estimates in Table 5.

The survey asked physicians about the impact of each of the following facilitators of EHR adoption: financial incentives for the purchase of an EHR system, additional payments for the use of an EHR, concerns about legal liability for not using an EHR, published certification standards, and protections against legal liability for record tampering. Response categories were major positive impact, minor positive impact, no

impact, minor negative impact, major positive impact. We report on the proportion of

physicians who responded that a facilitator would have a major positive impact.

Physicians were asked to report on the proportion of patients in their practice

who: were uninsured, were covered by Medicaid, were African American, were Hispanic,

and spoke a primary language other than English. Physicians were asked to estimate the

proportion separately for each group. Response categories for each were less than 10%,

10% to less than 25%, 25% to less than 50%, or 50% or more. For each variable,

responses were dichotomized into less than 25% and 25% or more. These variables were

included in a cumulative logit model that adjusted for all of the other variables shown in

Table 3. None of the variables were a significant predictor of EHR availability.