Incomplete EHR Adoption: Late Uptake of Patient Safety and Cost Control Functions

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Abstract:

Many functions important to realizing the full potential from electronic health records (EHRs) may not be selected by all physicians using EHRs in the ambulatory setting. This article examines the extent to which EHR systems used by Florida physicians include functionalities that the Institute of Medicine has designated as being critical for optimal performance. Results indicate that EHR systems used by recent adopters, when compared with early adopters, appear to be missing key patient safety and cost control functions. Overall, many physicians are only partially adopting EHR technologies, suggesting that published adoption rates may be exaggerating the true rate of diffusion. (Am J Med Qual 2007;22:319-326)

Keywords: electronic health records; diffusion of innovation; EHR functionalities; innovators; early adopters; early majority

Article:

INTRODUCTION

The widespread adoption of electronic health records (EHRs) promises to improve clinical out-comes, increase patient safety, and help control costs.[1-4] As such, the US Department of Health and Human Services (DHHS) has been working assiduously since 2004 to promote the nationwide use of EHR systems.[5] Although significant progress has been made, a report issued by the Government Accountability Office stated that DHHS's strategic framework "lacks detailed plans, milestones, and performance measures" with respect to making EHR use the standard of care.[6] One performance measure that is lacking is the degree to which physicians use the specific EHR functionalities that most directly affect quality, safety, and costs.[7]

EHR systems are composed of several distinct technologies, or functionalities, that must be used in an integrated manner to realize their full potential. It is possible for physicians to partially adopt an EHR system by using only selected functionalities in their medical practice. Furthermore, the functionalities that most directly contribute to patient safety, such as clinical decision support and electronic prescribing tools, are among the more complex to implement and use. Greater technological complexity reduces end users' willingness to adopt a functionality. Widespread partial adoption of EHR technology may occur[8] without realizing the hoped-for gains in clinical outcomes, patient safety, and cost control. Therefore, measuring both the EHR implementation rate and the degree of functionality adoption are critical to achieving the ends envisioned by DHHS.

The purpose of this article is to explore the number and types of EHR functionalities used by physicians with particular emphasis on whether the timing of adoption has an impact on physicians' choices in selecting available EHR functionalities. First, we develop a conceptual framework for our study by briefly describing the Technology Acceptance Model's (TAM) roles in predicting EHR adoption rates and the degree to which system capabilities are implemented by physicians. Next, we present the attributes of

EHR systems currently being used by physicians in Florida. Focusing on 1 state allows us to take an in-depth look at the use of EHR systems in a market where regulatory, reimbursement, and medicolegal issues do not vary. Third, guided by the TAM model, we examine the relationship between the length of time since EHR adoption and the use of key functionalities. Finally, conclusions and policy implications are discussed.

The current study makes 3 new contributions to the EHR research literature and policy debate. First, it empirically provides important insights into the likely patterns of EHR functionality use that different adopter types (eg, early and late adopters) will implement. Next, it allows policy makers to better understand how promoting EHR diffusion without considering partial adoption scenarios potentially threatens their goals of improving clinical outcomes, increasing patient safety, and controlling costs. Third, it provides estimates of EHR diffusion rates across varying levels of technology functionality.

BACKGROUND
On our survey, we defined EHR as a paperless form of the medical record that requires the provider to enter patient information (ie, clinical notes) into a computer system. Empirical estimates of physicians' EHR adoption rates vary widely and are dependent on the definition of "full" or "partial" use employed in the survey instrument.[9] General estimates of EHR adoption rates[10-13] may systematically mask or over-state the true nature of the system functionalities currently being used in the health care environment. This problem arises because EHR systems are really several technologies (eg, clinical data warehousing, decision support, order entry) bundled together. Furthermore, physicians can accept or reject various functionalities depending on costs and their assessments of importance versus ease of use. Therefore, to accurately map and predict the technology adoption life cycle, it is necessary to understand the various functionalities that comprise an EHR and how different groups of physicians decide which technologies to accept or reject. As an aside, it is important to mention that EHR implementation results in significant disruption to existing workflows. Furthermore, poorly implemented systems could pose challenges for office staff, physicians, and patients by introducing unintended consquences.[14]

Technology Acceptance Model
The TAM provides an explanation of the determinants of computer acceptance that predict potential users' likely behaviors across a broad range of end user computing technologies.[15] The major determinants of acceptance and adoption are defined by Davis (1989) as "perceived usefulness" and "perceived ease of use."[16] Perceived usefulness is "the degree to which a person believes that using a particular system would enhance her or his job per-formance,"[16(p320)] and perceived ease of use is "the degree to which a person believes that using a particular system would be free of effort." [16(p320)] It has been empirically demonstrated that the TAM explains the adoption of information technologies by different adopter groups (ie, innovators, early adopters, early majority, late majority, laggards).[17]

Innovators and early adopters are critical to the acceptance of a new technology. These individuals are risk takers, have above average levels of technical competence, and enjoy adopting new technologies for their own sake. In addition, these groups of adopters are likely to gravitate toward environments that can afford to invest in unproven technologies. In health care, such adopters are often younger[18] and work in larger, multispecialty groups.[10,12] Collectively, innovators and early adopters represent approximately 16% of the market for a new technology.

The next major segment of adopters is the early majority and constitutes about 34% of the market. This group is critical to the full diffusion of any technology because they are driven by a strong sense of practicality when deciding whether or not to adopt.[19] In particular, they evaluate the trade-off between a technology's usefulness and its ease of use. Effectively, the early majority determines if a technology will reach the "tipping point" in the marketplace.

Achieving the acceptance of the early majority may ensure commercial success, but it does not necessarily translate into the complete diffusion of a technology as called for by policy makers.[21] The late majority and laggards, who together constitute half the market, are generally skeptical of new technologies. These 2 cohorts' members are typically, but not always, older and work in smaller practices. [13,18]

General Hypothesis

Overall, innovators and early adopters have been found to adopt technologies in a comparable fashion, with the latter doing so slightly later. [22,23] It is in the interval between the early adopters and the early majority where the adoption "chasm" exists.[24] Those who adopt later tend not to embrace technologies to the extent of innovators and early adopters. Therefore, related to the EHR functionality adoption patterns, we postulate as follows: When compared to innovators and early adopters, those who adopt later will use fewer EHR functionalities in their systems.

METHODS

The data presented here are a subset from information collected in the spring of 2005 as part of a large-scale study of information technology use among physicians practicing in Florida. The study, approved by the Florida State University institutional review board, included a mailed survey to all primary care physicians (ie, family physicians, general internists, general pediatricians, obstetrician-gynecologists) in the state. In addition, 25% of other physicians practicing in an ambulatory setting (eg, medical and surgical specialists, general surgeons, dermatologists, psychiatrists) were randomly selected from the Florida Department of Health's list of physicians with clear and active licenses.

The survey instrument asked physicians to indicate what types of information technologies were being used in their medical practices. Those who indicated that they were currently using an EHR system were further asked to specify the year in which their system was installed. In addition, they were asked to identify the EHR functionalities commonly used from a list of functions derived from the Institute of Medicine's list of desirable EHR attributes.[25] The list of functionalities included items such as "clinical notes," "medication lists," "patient scheduling," and "electronic prescribing of medications." A complete description of the survey methodology, [18] including an analysis of potential response bias (none detected),[26] has been published previously. A copy of the survey instrument is available online as part of a previously published article.[27]

Statistical Analyses

To examine the frequency of functionality avail-ability in EHR systems, we used standard descriptive statistics. In addition, we analyzed the extent to which functionality use varied across those who adopted their EHR system at different times. Based on the adoption curve calculated from the temporal EHR utilization data (Figure 1), we were able to classify EHR users as being in the "innovator," "early adopter," or "early majority" adoption categories. Innovators were defined as having installed their EHR system [10] or more years ago. Early adopters included all physicians whose systems were installed 3 to 9 years ago. Those who adopted their EHR system 2 or fewer years ago were classified as being in the early majority, based on diffusion theory.[28] The variable representing these 3 categories was then specified as an independent variable in a series of logistic regression models that were used to calculate adjusted odds ratios. Each regression was limited to current EHR users only (n = 995) and predicted the availability of a given EHR function. Each model also controlled for various practice characteristics that were collected as part of the survey. Control variables included practice size, practice type (single or multispecialty), and practice scope (primary care vs other). Practice size was categorized into 4 levels representing the number of physicians at a given practice location (solo, 2-9, 10-49, or 50+).

RESULTS

A total of 4203 surveys were returned for a response rate of 28.2%. The demographics of respondents did not differ from the known demographics of Florida physicians.[29] Of the 4203 physicians, 995 (23.7%)

indicated that they are currently using an EHR system. Of those with an EHR system, approximately a quarter (26.6%) reported adopting their sys-tem within the last 2 years (early majority). More than half (55.5%) of current EHR users implemented their systems 3 to 9 years ago (early adopters). The remaining 17.8% of respondents have had their systems for 10 or more years (innovators). The demographic characteristics of these EHR users appear in Table 1.
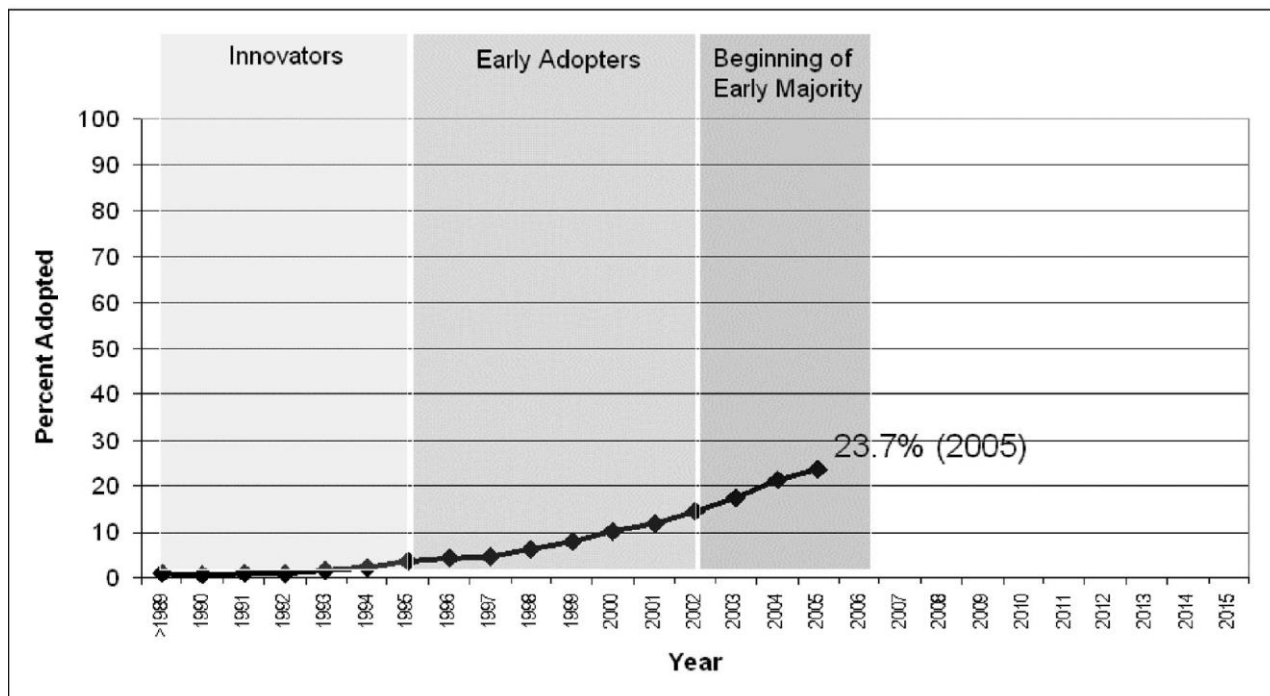

Figure 1. *EHR adoption curve among Florida physicians, 1999-2005.*
Source: Innovators, early adopters, and early majority are terms based on Rogers' Diffusion of Innovations.[19] Innovators are typically described as venturesome and have a greater propensity to take risk. Early adopters are typically social leaders and well respected among their peers. Those in the early majority are often deliberate and have many informal social contacts.

Table 1

Demographic Characteristics of EHR Users Expressed in Percentages (N = 995)

Demographics	Years Since EHR Adoption			
	0-2 Years (Early Majority) n = 245	3-9 Years (Early Adopters) n = 511	10+ Years (Innovators) n = 164	P value
Gender: male	78.5	76.8	78.4	.881
Practice size:				
Solo practice	22.2	20.8	12.8	
2-9 physicians	52.1	47.6	37.8	
10-49 physicians	17.1	17.3	18.6	
50+ physicians	8.5	14.3	30.8	<.001
Practice type				
Single specialty	83.2	75.3	51.0	
Multispecialty	16.8	24.7	49.0	<.001
Physicians training				
Primary care[a]	44.5	49.0	49.1	
Other	55.5	51.0	50.9	.479
Average current physician age (years)	47.5	49.4	51.5	.002
Average age at time of adoption (years)	45.9	44.1	38.6	<.001

Where applicable, numbers may not add up to 100% because of rounding. Chi-square or analysis of variance (ANOVA) was used, as appropriate, to calculate the P value for the difference between groups.
a. Primary care included family physicians, general pediatricians, general internists, and general practitioners.

Table 2
Availability of EHR Functions by Year of System Adoption Among Physicians in Florida (N = 995)

| | | Adjusted Odds Ratios[a] for Differences in Functions Used | | |
| | | Years Since EHR Installation | | |
EHR Functions	Overall % N = 995	0-2 Years (Early Majority) n = 214	3-9 Years (Early Adopters) n = 266	10+ Years (Innovators) n = 382
Clinical notes	93.9			
Patient demographics	90.1			
Medication list	88.7			
Diagnosis	87.9			
Allergies	87.5			
Problem list	81.6			
Procedures	77.9			
Patient scheduling	72.5	1.00		1.88
Electronically available lab data/results	67.6			
Electronic prescribing of medications	60.8	1.00	2.39	3.41
Electronically available X ray results	59.2			
Electronic order entry (ie, labs, X rays)	55.3	1.00		1.92
Patient education materials	47.2	1.00	1.84	2.46
Off-site access/log-in capability	46.9			
Access to reference material	38.1			
Electronic connection to pharmacy info	37.7	1.00		1.75
Coding advice to physicians	37.5	1.00	1.95	2.99
Preventive service reminders	34.3			
Growth charting	30.8	1.00	2.43	2.94
Weight-based dosing calculations	25.6	1.00	1.89	
Clinical decision support	25.3			
Advance directives	23.1			
Auto-updated insurance coverage info	17.5			
Other EHR functions	4.6			

Data in table are ordered by most frequently used function. Reference category for logistic regression models is 0-2 years since EHR adoption. Empty cell indicates no significant difference at $P < .05$ level. Some survey respondents did not indicate the year since EHR installation.

a. Adjusted for practice size, practice type (single or multispecialty), and primary care practice (family physicians, general pediatricians, general internists, and general practitioners).

Approximately three quarters (77.6%) of all EHR users were male, and approximately half (47.8%) were practicing primary care. Innovators (those adopting EHR 10 or more years ago) were more likely to be in large group practices comprising 50 or more physicians and in multispecialty practice (all P values <.001). Last, even though average current age among innovators (51.5 years) was slightly and significantly greater, respectively, than both early adopters (49.4 years) and the early majority (47.5 years; P = .002), age at EHR adoption was significantly lower for innovators (38.6 years) than for early adopters (44.1 years) and the early majority (45.9 years; P < .00 1).

The observed rate of available EHR functionalities in physicians' systems is presented in Table 2. Overall, the frequency of functionalities' availability ranged from a high of 94% (for the clinical notes function) to a low of 17.5% (for automatically updated insurance information on patients). A total of 7 of the 23 key functionalities examined were available in 75% or more of the ambulatory EHR systems. In contrast, 11 key functionalities were not available in half or more of the respondents' systems.

The availability of several key functionalities was related to time since EHR installation, even after controlling for the factors described above. Generally, when differences existed, those in the early majority category were invariably less likely to have certain functionalities. For example, even though the patient scheduling functionality was available in 72.5% of all EHR systems, innovators were 1.88 (95% confidence interval [CI] = 1.01-3.55) times more likely to have this functionality than early majority users. Likewise, innovators were more likely than early majority physicians to have electronic access to pharmacy information (Odds ratio [OR] = 1.75; 95% CI = 1.09-3.10) in their EHR system.

When compared with respondents in the early majority category, innovators (OR = 3.41; 95% CI = 1.96-3.89) and early adopters (OR = 2.39; 95% CI = 1.47-3.89) were more likely to have the ability to electronically prescribe medications. Similarly, innovators (OR = 2.46; 95% CI = 1.43-4.25) and early adopters (OR = 1.84; 95% CI = 1.13-3.01) were more likely to have the ability to print patient education materials via their EHR system. Moreover, the growth charting functionality was more commonly found in systems used by innovators (OR=2.94; 95% CI = 1.56-5.54) and early adopters (OR=2.43; 95% CI = 1.36-4.33) compared with their colleagues who adopted more recently (early majority). Innovators (OR=2.99; 95% CI = 1.67-5.33) and early adopters (OR=1.95; 95% CI = 1.15-3.32) were significantly more likely to have coding advice to physicians as a feature in their EHR system. Last, early adopters were more likely than those in the early majority to report having weight-based dosing calculations in their EHR system (OR = 1.89; 95% CI = 1.03-3.47).

DISCUSSION

Several EHR functionalities have been identified by experts as having important patient safety and quality-of-care implications.[25] Despite the growing data on EHR adoption rates, little is known about the configuration of EHR system attributes being adopted and used. This study examined the availability of key functionalities in the EHR systems of physicians in Florida and examined if function utilization differed among adopters of different time frames.

Overall, considerable variation in the availability of key system attributes was noted. Basic EHR attributes (eg, clinical notes) were more prevalent than more complex ones (eg, electronic order entry), and no single functionality was universally available in the EHR systems examined. Surprisingly, even simple functionalities such as problem lists or procedure lists were only available in approximately 8 of 10 EHR systems used by respondents. Moreover, functionalities that are directly related to improved quality, such as preventive service reminders, clinical decision support, access to reference materials, or the ability to print patient education materials, were not available in the majority of EHR systems. Furthermore, system attributes such as electronic prescribing of medications, which have been linked to improved patient safety[30,31] and averted costs,[32] were available in only approximately 6 of 10 EHR systems despite their significant coverage in the medical literature [33-35] and popular press.[36-38] Overall, it appears that greater technological complexity reduces end users' willingness to adopt a functionality.

The variability of key functionalities' availability would suggest that published estimates of EHR adoptions may be overestimating the true level of "meaningful" system availability. Many of the benefits from EHR stem from the 10 most frequent functionalities listed in Table 2, and several of those functionalities are not available in a quarter (or more) of current EHR systems. If these trends hold true in other geographic locations, the realistic EHR adoption rate may be 25% lower than published studies would suggest. In Florida, the overall 23.7% EHR adoption rate may more accurately be 17.8%, given that many current systems lack necessary EHR attributes. This percentage could be potentially lower depending on what level of EHR functionalities one would consider as the bare minimum acceptable.

It was hypothesized that recent adopters of EHR would report using key functionalities less frequently than other users. Indeed, in every case where differences existed, physicians in the early majority were less likely to report the use of key functionalities in their EHRs. Furthermore, the attributes that were frequently lacking in recently adopted systems tend to hold the most promise for improving patient safety and providing other important benefits. For example, electronic prescribing of medications and coding advice to physicians were approximately one half to one third as likely to be present in systems that were recently adopted. Moreover, patient education materials were most frequently available in systems used by innovators and early adopters. The lack of these functionalities in an EHR system raises questions about the potential to improve care and reduce costs.

The TAM suggests that innovators are venture-some and have a greater propensity for risk taking. On the other hand, those in the early majority are less tolerant of uncertainty and typically possess less technical knowledge regarding the innovation. These characteristics have been shown to greatly influence adoption decisions among physicians.[39,40] With respect to EHRs, the commitment from a physician to adopt is followed by a series of more subtle choices regarding the level of adoption to pursue.

To date, these more understated choices, which include the types of EHR functionalities used, have been largely underappreciated by researchers and policy makers. Ironically, the very reasons why those in the early majority did not adopt EHRs sooner (eg, less technical knowledge, lower threshold for risk) may explain why they lag on the adoption of certain critical functionalities. The functionalities that are not being adopted (eg, electronic prescribing, order entry) are those that typically require the most considerable changes to existing processes and work flow. As a result, they increase the level of uncertainty and the possibility of implementation failure—2 traits that are unacceptable to many in the early majority. This is particularly concerning because the functionalities not being adopted are also those with the greatest potential to improve safety and lower overall costs. It would appear, therefore, that continued incomplete EHR adoption by the early majority raises red flags about the eventual widespread realization of EHR benefits.

Despite the valuable information provided in the current study, several limitations are worth mentioning. First, the cross-sectional nature of this study is better suited for identifying trends rather than deter-mining causality. Therefore, despite the fact that the trends in the data are supported by the TAM conceptual framework, it is possible that physicians expand the capabilities of their EHR systems longitudinally. Future research should monitor EHR adoption, by function, over time. Next, this study may be limited by common issues associated with survey research, including willingness of respondents to participate and give accurate information and the possibility of response bias because of a suboptimal response rate. However, as mentioned above, our previous analyses of the current data[26] suggest that response bias was likely minimal. Last, the current study focuses on only 1 state; therefore, generalizations to other regions should be made with caution.

In conclusion, the data presented herein raise important policy questions regarding EHR adoption in 1 state. Confirmation of these findings from other locales will be needed to formulate policy interventions to ensure the widespread adoption of key EHR functionalities nationally. Performance measures, including the monitoring of key EHR functionalities, should be an important component of DHHS's revised plan.

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