

Department of Health and Human Services
Office of the Assistant Secretary
for Planning and Evaluation (ASPE)

**ASSESSING THE ECONOMICS OF EMR
ADOPTION AND SUCCESSFUL
IMPLEMENTATION IN PHYSICIAN SMALL
PRACTICE SETTINGS**

Final Report

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Moshman Associates, Inc

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1.0 Executive Summary

Electronic Medical Records (EMRs)ⁱ are increasingly viewed as a means of achieving improved health care quality and reduced costs. In 2004, President Bush announced a 10-year goal of making EMRs available to most Americans. To help achieve this goal, he issued an executive order that established the Office of the National Coordinator (ONC) for Health Information Technology (HIT).¹ The executive order also emphasized the importance of:

- ▶ Establishing evidence on costs, benefits, and outcomes associated with HIT implementation
- ▶ Reducing the risks that providers face in making HIT investments.

In addition to the executive order and the establishment of ONC, a number of public and private sector initiatives have focused on promoting the adoption of HIT. These include community-focused initiatives such as those funded by the Agency for Healthcare Research and Quality (AHRQ), physician-focused initiatives such as the Doctor's Office Quality-Information Technology (DOQ-IT) program, and standards-focused initiatives such as the establishment of e-prescribing standards under the Medicare Modernization Act (MMA).

Despite these initiatives, the adoption of EMR has been limited, and adoption rates vary widely across care settings. Recent surveys suggest that adoption rates in ambulatory settings range between 15 and 18 percent.^{2,3} This overall rate of adoption masks significant variations among the kinds of EMR functions adopted and the kinds of practices that are adopting them. For example, Burt and Sisk found that practices with more than 20 physicians have approximately three times the adoption rate of solo practices and twice the adoption rate of practices with fewer than 10 physicians.⁴

With approximately 75 percent of physician practices employing fewer than nine physicians, such low adoption rates among small practices does not bode well for the national goal of achieving broad EMR diffusion in 10 years.⁵ Low rates of EMR adoption have been attributed to a variety of forces, including misaligned financial incentives, lack of standardization among EMR applications, and the high turnover of HIT vendors.⁶ There are few studies, however, that have examined, at a microeconomic level, the various economic and noneconomic factors that promote or deter EMR adoption in small practice settings. Understanding these factors and their relative importance to EMR adoption would be critical to establishing policies that can promote adoption.

To provide a deeper understanding of the factors that impede or impel EMR adoption, the Office of the Assistant Secretary for Planning and Evaluation (ASPE) in the Department of Health and

ⁱ The reader should note that although a variety of terms are often used interchangeably, such as EMR (electronic medical record) or EHR (electronic health record), we have used the term EMR throughout the report except when citing the work of other authors who used alternative terminology.

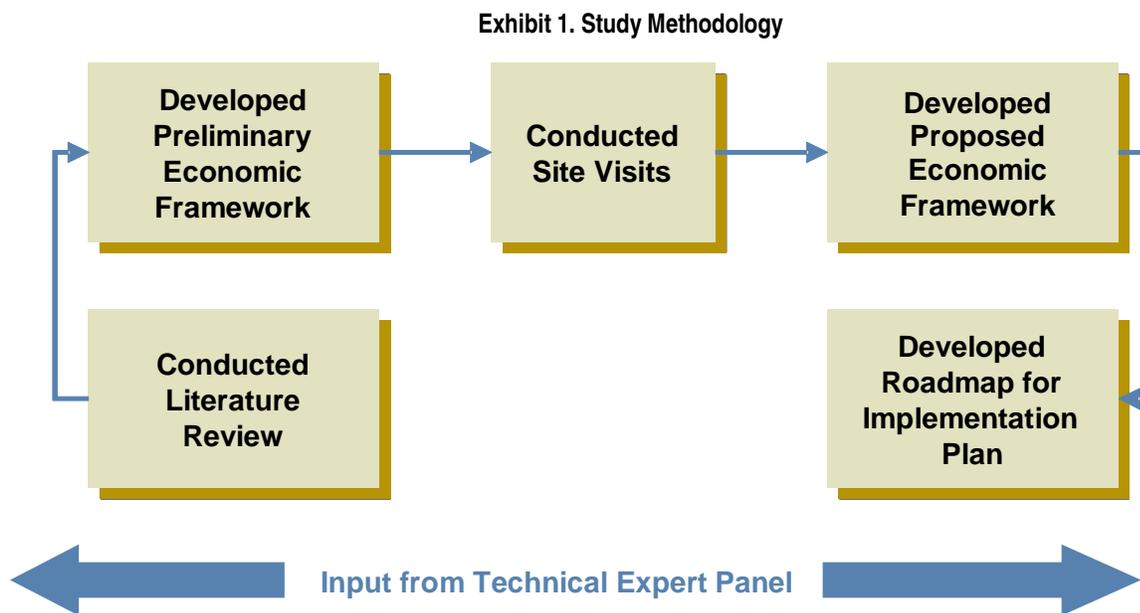
Human Services (HHS) recently engaged Moshman Associates and Booz Allen Hamilton to assess the economics of EMR adoption and implementation in physician small practice settings. This study, which was originally envisioned as a two-phased approach, has been focused primarily on the following:

- ▶ Understanding the factors that influence EMR adoption in small practices
- ▶ Developing a microeconomic framework that incorporates these factors.

This framework can serve as the foundation for a formal microeconomic model in a second phase of analysis. Using appropriate data, this microeconomic model can be estimated to derive individual practice EMR adoption curves that can be aggregated to derive industry-level adoption curves. The model can also be used to examine the relative importance of factors affecting EMR adoption and the magnitude of that impact.

1.1 Study Methodology

The methodology for our study is shown in Exhibit 1.



1.2 Literature Review and Synthesis

We conducted an in-depth review of the following domains in the peer-reviewed and “grey”ⁱⁱ literature:

ⁱⁱ Grey literature refers to publications produced by government, academia, business, or industry. It includes reports, conference proceedings, working papers, government documents, and other literature that has not been published in a peer-reviewed journal.

- ▶ EMR system characteristics
- ▶ HIT, specifically EMRs, and their impact on healthcare safety, quality, efficiency, and effectiveness
- ▶ EMR cost-benefit and return on investment (ROI) studies
- ▶ Physician and practice characteristics relevant to EMR adoption
- ▶ Technology adoption models from the economics and sociology literature.

The process for the literature review involved identifying articles through structured searches of PubMed, Econlit, Ovid, and other databases. Articles were evaluated based on topical and temporal relevance and methodological approach. In total, more than 350 articles were screened; of these, about 189 are cited in this study. In this section we describe the major findings from the literature review.

1.2.1 Overview of literature findings

Definition of EMR

A common understanding of what is meant by the term EMR and the other terms frequently used to describe this technology is important to this study for a variety of reasons. In a study of technology adoption, it is essential to understand what type of technology is being adopted in order to accurately characterize the technology in an economic framework. In addition, alternative characterizations of the technology can lead to variance in estimates of adoption rates and estimates of costs and benefits. It would be optimal to understand which clustering of functionalities physicians adopt, and what factors (e.g., practice characteristics, income, specialty type, and others) correspond to adoption of different functionality clusters. In our review of the literature, we were unable to identify any survey that made such correlations. Finally, it is important to understand the alternative definitions of EMR because these definitions and functionalities correlate with varying costs and benefits.

The literature reveals a heterogeneous set of definitions, standards, and functional models of EMR. Brailer and Tersasawa (2003) cite 13 different terms used to refer to EMR.⁷ In addition to these definitions, there are a variety of functional models, both theoretical and empirical, that have been used to describe an EMR. A number of organizations have developed theoretical EHR/EMR functional models, including the Healthcare Information and Management Systems Society (HiMSS), Health Level Seven (HL7), Gartner, and the Institute of Medicine (IOM).

Empirical characterizations of EMR functionality are derived from either the cost-benefit or survey literature. Wang classified EMRs in three categories based on functionality clusters: basic (documentation and viewing), intermediate (very basic e-prescribing and decision support), and advanced (more sophisticated order entry and decision support).⁸ Gans provides an empiric perspective by describing the functionalities actually adopted by office-based physicians based on survey data (see Exhibit 2).

Exhibit 2. EHR Capabilities as a Function of Number of Physicians in a Practice (Gans)⁹

EHR Feature/Capability	Percent Adoption by Practice Size			
	≤ 5 physicians	6–10 physicians	11–20 physicians	21+ physicians
Patient demographics	99	99	99	100
Visit/encounter notes	98	96	99	98
Patient medications	96	97	98	98
Past medical history	95	95	99	95
Problem lists	94	93	94	96
Laboratory results	89	87	94	97
Radiology/imaging results	75	72	87	89
Tracking immunizations	80	72	64	75
Drug interaction warnings	79	75	81	84
Drug reference information	76	80	78	79
Drug formularies	62	64	67	68
Clinical guidelines and protocols	64	62	71	64

Within these categories of functions there are varying levels of sophistication, such as the level of decision support in medication ordering, alerts, and provision of guidelines. Different functionalities have different implications for performance as well as for costs and benefits.^{10,11} In addition to functionality, usability has implications for performance, costs, and benefits. Though not well measured, assessed, or reported in the literature, experts suggest that usability can have a significant influence on physician use of an EMR.

Despite the long history of heterogeneous terms and definitions being used in the literature, some standards are emerging that may help codify the functional characteristics of an EMR from a market perspective. In support of President Bush’s 10-year goal, ONC and the American Health Information Community (AHIC) set the specific goal of private sector certification of HIT products such as EMRs. As a result, the Certification Commission for Health Information Technology (CCHIT) was created, and charged with certifying electronic health records based on the minimal standards of functionality, interoperability, and security that a tool should possess. In July 2006, CCHIT announced achievement of certification status by 20 EHR products. This certification is significant because it introduces a certain level of standardization across vendors and provides valuable information to potential adopters.

The Role of EMRs in Promoting Health Care Quality

The Institute of Medicine (IOM) has articulated six aims of quality: safety, effectiveness, efficiency, patient-centeredness, timeliness, and equity.¹² We reviewed the quality literature from the perspective of the following three aims of quality: the evidence for the impact of EMRs on safety, adherence to evidence-based guidelines, and provider efficiency. Examining the evidence that links EMRs and quality improvement is important to this study for a number of reasons. First, physician surveys suggest that quality enhancement is an important motivator of physician adoption.^{13,14,15} Physicians may have been influenced by this literature either by reading it themselves, or through peers and leaders who are familiar with this body of research. The

strength of the evidence, or the manner in which physicians perceive the evidence, may be a factor in influencing the decision to adopt EMRs in their own practices. In addition, estimates from these studies have been used in the EMR cost-benefit and ROI literature. Understanding the strength of this evidence is critical to the evaluation of cost-benefit studies.

The Role of EMRs in Promoting Safety

An examination of the literature on incidence and prevalence of errors in the ambulatory care environment yields these key findings:^{16,17,18,19}

- ▶ ADEs in ambulatory care appear to be fairly common, for example with rates of 5.5 per 100 patients.²⁰
- ▶ Approximately one-quarter to one-third of ADEs in an ambulatory care environment may be preventable by using such tools as computerized prescribing.
- ▶ The preponderance of errors leading to adverse patient outcomes is related to prescribing, monitoring, and dispensing.

Given these findings, the potential of EMRs, and more specifically computerized physician order entry (CPOE), to promote safety may resonate with physicians who place particularly high priority on the professional imperative to “first do no harm.” This may be highly relevant to “innovators” who, according to Rogers, are more likely to embrace new ideas and may be characterized as “believers.”²¹ However, physician survey data continue to suggest that some physicians, especially those who work in smaller offices, feel the evidence supporting the benefits of EMR is weak.²² A critical assessment of this literature supports that perspective. There are two major limitations associated with this literature. First, the majority of studies are focused on the inpatient environment, and their relevance to the ambulatory environment requires extrapolation. Second, the evidence from these studies appears to be inconclusive.

Bates and colleagues evaluated the impact of CPOE in preventing medical errors in three medical units over 4 years.²³ In 2001, Bates found an 86 percent reduction in error rate over the study period that was correlated with the level of system functionality. Evans²⁴, Mullett²⁵, Potts²⁶, and Fortescue²⁷ also found safety improvements in inpatient environments with decision-support tools. Though numerous studies have correlated EMR and CPOE use with improved quality and safety, a number of recent studies have shown ambiguous or negative effects of CPOE with lower levels of functionality or usability. Gandhi found no significant difference in error rates between sites with hand-written prescriptions and those with basic computerized prescribing.²⁸ Koppel²⁹ and colleagues identified 22 categories of error they attributed to a CPOE, and other studies have found unfavorable evidence. Han has associated a CPOE implementation with increased mortality in a pediatric ICU environment.³⁰ In studies where either safety was compromised or had not improved significantly, the authors generally attributed these outcomes to inadequate functionality, poor usability, or inadequate training and modification of human processes.^{31,32,33,34}

The Role of EMRs in Promoting More Effective Care

Evidence-based medicine is an approach to improving both the effectiveness and the efficiency of care. This is accomplished by promoting care shown to be effective and by limiting wasteful care that is less effective or perhaps even harmful. The literature suggests that much of the health care provided today is not evidence-based.^{35,36} EMRs have the potential to improve effectiveness of care.

The Veterans Health Administration (VHA) was an early adopter of EHRs, and its system supports clinical reminders and suggestions for a broad range of clinical services, including screening and prevention. For a number of these interventions, the VHA has significantly higher rates of compliance with recommended guidelines when compared with Medicare populations.³⁷

In a study focused on the provision of electronic guidance to pediatric providers, Margolis showed increased compliance with protocols for otitis media and pharyngitis.³⁸ However, the physicians found the required documentation to be onerous and refused to use the system after 5 weeks. In a randomized study, Christakis and colleagues provided one group of pediatric providers with real-time electronic advice regarding a shortened course of antibiotic therapy for otitis media, resulting in a 34 percent increase in prescribing the recommended therapy when compared with the control group.³⁹ Evidence from Safran, Christakis, Evans, and others suggests that, especially in the domain of medication administration, HIT can promote more appropriate and more cost-effective care.^{40,41,42}

However, the evidence for the impact of EMRs on effectiveness of care is also ambiguous. Some studies that have examined evidence-based treatment suggestions for asthma, hypertension, diabetes, and coronary heart disease have found no improvement, or marginally improved compliance among physicians.^{43,44,45}

In addition to the lack of conclusive evidence on EMR-induced physician compliance, there appear to be ambiguities in correlating compliance with quality outcomes. Tierney examined the impact of providing electronic evidence-based cardiac care suggestions to primary-care physicians and pharmacists, and found no impact on quality of life, medication compliance, utilization, or costs.

Role of EMRs in Promoting Efficiency and Controlling Cost

In reviewing this segment of the literature, we focused largely on four aspects of efficiency and cost reduction: cost savings associated with reduction in ADEs, reduction of unnecessary lab tests, cost-efficient prescribing practices, and the promotion of time-efficient provider workflows.

The cost savings from preventing adverse drug events (ADEs) have been estimated in both inpatient and ambulatory environments. Classen estimated the average cost of adverse drug events to be approximately \$2,262 per event within an acute care setting. This estimate is similar to the cost estimates in the ambulatory setting. Field estimated the cost of preventable adverse drug events in the ambulatory setting to be approximately \$1,900 per event.^{46,47}

Redundant and unnecessary testing is a source of inefficiency and unnecessary patient burden. Bates estimated that 8.6 percent of hospital laboratory tests are redundant and demonstrated that a significant number of tests (69 percent) may be canceled when providers are so advised electronically.⁴⁸ In three prospective randomized controlled studies, Tierney and other investigators found that physician testing behavior could be favorably influenced by providing different kinds of electronic information (e.g., previously ordered tests, pretest probability of a positive test, and test cost) at the time of ordering.^{49,50,51}

Using appropriate generic drugs or substitution with a more cost-effective alternative may be a significant source of savings. Evans found that an anti-infective management system with robust decision support significantly decreased medication costs and was associated with shorter and less expensive hospital stays.⁵² Teich and colleagues found that a CPOE system promoted increased use of a more cost-effective histamine blocker.⁵³ Mullett used network health plan data to demonstrate that an e-prescribing system produced an average savings of \$465 per member per month (PMPM) for new prescriptions, and \$873 PMPM when all pharmacy claims were considered.⁵⁴

The literature regarding the impact of EMRs on provider efficiency is largely focused on the inpatient environment. Conclusions vary significantly and are often different for physicians and nurses. In a review of the literature, Poissant and colleagues found that bedside terminals and central station desktops reduced nurse documentation time by about 25 percent. However, physician documentation increased in both cases, though most significantly when using a central station desktop.⁵⁵

There has been relatively less focus on EMRs and workflow efficiencies in the ambulatory environment; however, multiple authors note that efficiency and productivity often decline in the immediate post-implementation period and may persist for months.^{56,57,58} Overhage and colleagues found that an outpatient EMR initially increased encounter time per patient by 2.12 minutes and Shu found that the time spent on patient order entry increased from 2.1 to 9 percent of the workday after the implementation of an inpatient CPOE.^{59,60} Pizziferri found that the average time for clinical documentation was reduced by 0.5 minute with EMR usage; however, only 29 percent of those completing the survey felt that the EMR could improve the documentation times.⁶¹

EMR and Quality – Summary Points

Studies that have examined the impact of EMRs on quality vary in age, methodological rigor, and generalizability. There are, however, a few major themes that emerge from an examination of the literature on EMRs and their impact on safety, effectiveness, and efficiency. First, there are fewer studies focused on the ability of EMRs to improve safety, effectiveness, and efficiency in the ambulatory environment than in the inpatient setting. Second, the evidence regarding the impact of EMRs on safety, effectiveness, and efficiency is, at times, ambiguous or contradictory. Third, the ability of EMRs to generate these benefits depends on a number of factors, including levels of functionality, usability, and integration with workflow processes. In addition to the ambiguity associated with the ability of EMRs to generate these benefits, physicians' realization

of benefits is also uncertain and depends on how the physicians are reimbursed. This uncertainty, which is related to the both the generation and realization of benefits, may deter physician adoption of EMRs.

EMR Cost-Benefit and ROI

An examination of the literature on EMR costs, benefits, and ROI is important because estimates of costs and benefits are central to the EMR adoption decision. Physicians cite excessive cost in relation to uncertain benefits as an obstacle to EMR adoption. It is also important to understand the relationship between net benefits (benefits minus costs) and system functionality, mode, sequence, and pace of implementation.

We identified nine ROI studies of note in the peer-reviewed literature; these are listed in Exhibit 3. Only four focus exclusively on the ambulatory environment. The calculations of these costs and benefits are, on the margin, extremely important to decision-making in microeconomic models of technology adoption. In addition, the net benefit or ROI literature is important because its positive findings are widely cited and may influence physician expectations regarding net benefit.

Exhibit 3. EMR Cost-Benefit Studies

Interoperability ROI	Inpatient/IDN ROI	Ambulatory ROI
Walker, et al./CITL, 2005; projected large ROI by creating a national interoperable network of EMRs ⁶²	Birkmeyer, et al., 2002; showed positive ROI for CPOE implemented in 200-bed and 1,000-bed hospital ⁶³ Kian, et al., 1995; projected positive ROI at MD Anderson Cancer Center ⁶⁴ Schmitt & Wofford, 2002; projected strong ROI at Virginia Mason Medical Center ⁶⁵	Wang, 2003; model predicted strong ROI for advanced ambulatory EMRs ⁶⁶ Johnston, et al./CITL, 2003; model predicted strong ROI for advanced ambulatory CPOE ⁶⁷ Miller, et al., 2005; retrospective assessment of 14 physician practices showed positive ROI ⁶⁸ Khoury, 1998; showed positive ROI of older system for large Kaiser practice ⁶⁹
Hillestad, et al., 2005; projected positive net benefit of EMR adoption in inpatient and ambulatory settings ⁷⁰		

All nine ROI studies that we reviewed described a strongly positive net benefit associated with EMR adoption. As noted earlier, only four of the nine ROI studies focused on the ambulatory environment. Of these, Wang and Miller focused on EMR adoption, and Johnston examined CPOE adoption in smaller practices. However, only Miller used empirical measurement of actual costs and benefits to estimate ROI.⁷¹

Costs at the individual practice level vary significantly in response to a variety of factors, including functionality, practice size, and negotiating capabilities, and the per-physician cost in these studies ranged between \$33,000 and \$43,000. The costs accounted for in the literature include one-time acquisition and implementation costs as well as ongoing annual costs. There are, however, other kinds of costs associated with EMR adoption that have not been well accounted for in the literature. These include costs associated with researching and selecting a

vendor, costs related to the customization and selection of the right sets of functionalities, and costs associated with technology obsolescence. All of these costs have been cited by physicians as being relevant to their EMR adoption decision.^{72,73,74,75,76} For small practices, these costs can be significant and may deter adoption.

Wang estimated that physicians working in highly capitated environments using EMRs with the most robust functionality would realize a net savings of \$86,400 per physician over 6 years.⁷⁷ Miller estimated that the average net benefit in these 14 practices was approximately \$33,000 per FTE provider per year. Miller's study was based on retrospective empirical measurement of net benefit, in contrast to Wang, who relied on a projection model.

Although Wang and Miller both described a positive ROI with EMR adoption in small offices, they arrived at this conclusion in different ways.^{78,79} Wang's model attributed the net benefit to reduced ADEs and redundant lab tests, and more cost-effective prescribing practices.⁸⁰ This benefit was strongly associated with a capitated reimbursement environment. In contrast, Miller did not find that these factors contributed significantly to the net benefit in the 14 practices he studied. Rather, net benefit was driven by the reduced labor costs associated with lower transcription and file room costs, and increased revenue from better documentation and coding.

In summary, the cost-benefit literature, especially as it pertains to the ambulatory environment, is limited. Most estimates of cost, benefit, and net benefit are based on projection (simulation) models rather than on empiric measurement, and many of these studies rely heavily on expert opinion and extrapolations from other literature sources.^{81,82,83,84} We identified one study that conducted an empiric assessment of costs and benefits in the ambulatory environment.⁸⁵ We identified no studies that prospectively measured the pre-implementation baseline and then assessed costs and benefits post-implementation. The limitations of this literature reveal an evidence gap that may influence physician adoption by contributing to the uncertainty regarding expected benefits.

Practice and Physician Characteristics that Influence EMR Adoption

In creating an economic framework of EMR adoption, it is critical to capture physician and practice characteristics that correlate with adoption. Here, the physician survey literature proved to be useful. Although there are many surveys of physician adoption, they vary greatly in quality and relevance. We identified a limited number of methodologically sound surveys relevant to physician EMR adoption, including surveys by Audet,⁸⁶ Gans,⁸⁷ Burt and Sisk,⁸⁸ the American Academy of Family Physicians,^{89,90,91,92} and the Medical Records Institute.⁹³ These surveys suggest that between 15 and 18 percent of physician practices have adopted an EMR.^{94,95} The practice characteristics that correlated with adoption (either positively or negatively) included practice size, ownership structure, means of compensation, location, and specialty. The physician characteristics that correlated with adoption include age and medical specialty. We discuss some of the more significant correlations below:

- ▶ **Practice Size.** Propensity to adopt an EMR was strongly correlated with increased practice size. Burt and Sisk found that practices of 10 to 19 physicians were more than twice as likely to use EMRs when compared with solo practitioners.⁹⁶ Some authors

associate this with economies of scale that may be achieved in larger practices.^{97,98,99}

Others suggest that access to capital and credit may be a more significant issue for smaller practices. This is a significant finding given that approximately 75 to 80 percent of physicians work in practices with nine or fewer physicians.^{100,101,102}

- ▶ **Ownership structure.** Burt and Sisk divided ownership structure into three categories: physician owned, HMO owned, and others, such as hospital owned. They found very strong correlations between adoption and ownership structure, with physician-owned practices being much less likely to adopt than practices in the other two categories. There is a correlation between practice size and ownership, with HMO-owned practices and those in the “other” category being significantly larger than physician-owned practices.¹⁰³
- ▶ **Compensation.** Salaried physicians were more likely to adopt, although salaried physicians are also more likely to work for HMOs and larger practices.¹⁰⁴
- ▶ **Specialty.** Different studies produced different results depending on the manner of specialty classification and methods of analysis. After excluding radiologists, pathologists, anesthesiologists, and dermatologists, Audet found that multi-specialty practices were more likely to adopt an EMR than were primary care practices.¹⁰⁵ When Burt and Sisk compared primary care and specialty practices, broadly defined, no differences in adoption behavior were noted. However, when behaviors were examined at the level of physician-specific specialties, Burt and Sisk found that proceduralists such as orthopedic surgeons, cardiologists, and otolaryngologists had the highest EMR use rates, while pediatricians, psychiatrists, and dermatologists had the lowest use rates.¹⁰⁶
- ▶ **Age.** Burt and Sisk found that physicians over 60 years of age were less likely to adopt, although Audet did not find a correlation with age.^{107,108}

While the physician and practice characteristics captured by these surveys are useful, they have limitations in supporting an effort to develop a microeconomic framework of physician adoption. First, many of the characteristics cited are nonmodifiable factors such as practice size, ownership structure, specialty, and age. While useful from a descriptive point of view, they do not provide policy makers with “levers” to influence adoption behavior. Indeed, a careful analysis of these factors suggests that they indirectly affect EMR adoption through their impact on a practice’s cost-benefit structure. For example, practice size may serve as a proxy for the practice’s ability to negotiate prices of costly technologies, to marshal resources to research the technology prior to adoption, or to absorb risk and uncertainty. Age may likely represent a broad range of personal characteristics that may influence adoption in different ways. On the one hand, for example, age is likely to correlate with income, with older physicians having higher income and net worth. These characteristics may encourage adoption. On the other hand, a physician nearing retirement will have a shorter time horizon over which to recoup his or her investment, making EMR adoption less attractive. The current literature does not address these nuances.

Another notable deficit of these surveys for our specific purposes is that they do not correlate adoption behavior and practice and physician characteristics with specific clusters of EMR functionality. It would be important to know how practice size, income, specialty, and appetite for risk correlate with the adoption of different kinds of functionality, as well as the costs and

benefits that are associated with that functionality. We sought to address some of these gaps by conducting site visits to physician offices. These visits are described in more detail below.

Physician Perceptions of EMR Benefits, and Barriers to Adoption

Unlike practice and physician characteristics noted in the surveys cited above, physician perceptions of costs, benefits, and barriers are modifiable. Ultimately, beliefs and expectations regarding costs and benefits drive individual purchase decisions and are relevant to an economic framework that describes adoption behavior. These attitudes may be influenced by published evidence, but they are also likely to be strongly influenced by peer networks.^{109,110} The five surveys previously cited provide useful insights into physician attitudes regarding EMR and are summarized below in Exhibit 4.^{111,112,113,114,115} We also draw on perceptions and adoption motivations cited by the 10 ambulatory Davies Award winners in 2003,^{116,117,118} 2004,^{119,120,121,122} and 2005.^{123,124,125}

Exhibit 4. Summary of Physician Perceptions of EMR Adoption Barriers

Audet, et al. ¹²⁶				Gans, et al. ¹²⁷		
Barrier	Percent			Barrier	Mean Rating	
					Practice w/ EHR	Practice w/o EHR
Startup costs	56.0			Lack of support from practice physicians	3.32	3.15
Lack of uniform standards	44.0			Lack of capital resources to invest in an EHR	3.31	3.58
Lack of time	39.0			Concern about physicians' ability to use EHR	3.18	3.40
Maintenance costs	37.0			Concern about loss of productivity	3.04	3.24
Lack of evidence of effectiveness	26.0			Inability to evaluate, compare, select EHR	2.60	2.86
Privacy concerns	21.0					
Lack of training	16.0					
AAFP, 2005 EHR Survey ¹²⁸				Medical Records Institute ¹²⁹		
Barrier	<10%	10–20%	>20%	Barrier	2003 (%)	2004 (%)
Affordability			+	Lack of adequate funding	64.2	55.5
Decreased productivity			+	EHR cost	32.3	36.0
Data entry cumbersome		+		Lack of support	37.2	35.4
Risk of vendor going out of business		+		EHR solutions that are fragmented	30.2	34.1
Lack of time		+		Creating a migration plan	29.2	27.6
Lack of expertise in selection		+		Meeting technical/clinical requirements	27.3	27.3
Partner acceptance		+		Inadequate health care information standards	22.9	27.3
Complex contracts	+			Difficulty in building a strong business case	21.9	24.7
Don't see value	+			Difficulty in evaluating EHR solutions or components	17.2	23.1
Technology burdensome		+		Lack of structured medical terminologies	18.1	16.9
Mistrust of vendors	+					
Privacy	+					
Miller and Sim ¹³⁰						
<ul style="list-style-type: none"> • High cost and uncertain benefits • High initial physician time costs • Technology — poor usability • Difficult complementary (workflow) changes 				<ul style="list-style-type: none"> • Inadequate support • Inadequate data exchange with other systems • Lack of incentives • Physician attitudes 		

Legend: + Positive correlation, with no statistical significance

Although these perceptions are nuanced and are summarized more adequately in the body of this report, some overarching themes, particularly with regard to barriers, emerge from the survey literature. Although each study approaches the issue of cost and affordability from a slightly different perspective, in all these studies cost and factors related to cost and affordability were consistently identified as significant barriers to adoption. Audet cites both startup and maintenance costs,¹³¹ Gans refers to the lack of capital resources,¹³² the AAFP survey highlights affordability,¹³³ and the MRI survey describes EHR cost and lack of funding.¹³⁴ In each of these, some measure of cost is consistently rated as one of the most significant obstacles, especially among physicians who have not adopted EHRs.¹³⁵

Costs cited were not confined to the direct cost of the EMR but also to time devoted to various stages of the adoption process. For physicians, particularly self-employed and non-salaried physicians, income is related to productivity or the number of patients they can see per unit time.¹³⁶ Perceived costs related to choosing an EMR were therefore often expressed in terms of time.^{137,138} As suggested by Rogers, highly complex technologies such as EMRs require significant investments of time prior to purchase, and such complexity, and the time costs associated with it, can be barriers to adoption.^{139,140} Physician concerns regarding complexity are expressed not only in terms of evaluating and using the technology but also apply to other aspects of adoption, including such activities as developing an RFP or a contract. Each layer of complexity has the potential to add cost, or perceived cost, from the physician's perspective. In addition, productivity loss associated with the early stages of implementing and learning a new technology was cited as a significant barrier, especially among those who have not adopted an EMR.^{141,142}

Uncertainty regarding the costs and benefits of a technology can be a barrier to adoption.^{143,144,145} Uncertainty of future benefit or net benefit was cited in three surveys and was expressed as "a lack of evidence of effectiveness," "difficulty in building a business case," or an inability to "see value."^{146,147,148} Some respondents expressed a fear that the vendor may go out of business, a fear that represents another source of uncertainty related to future costs and benefits.

Inadequate support from colleagues was highlighted as a concern in several of the studies,^{149,150,151} and among those who had adopted an EMR, this was the most highly rated barrier cited in Gans.¹⁵² Miller observed that physician champions in these practices embodied the attributes of Roger's innovators, and nonchampions were more easily discouraged.¹⁵³ In his view, such champions were essential to success.

Technology Diffusion Literature

We reviewed the technology diffusion literature to examine, from a theoretical perspective, the mechanisms by which new technologies proliferate and to identify theoretical constructs upon which to build an economic framework for EMR adoption in small practices. This review focused on two intellectual disciplines that dominate the technology diffusion literature: sociology and economics.

Sociology Literature. The sociology literature emphasizes the importance of interpersonal relationships and social networks in technology diffusion. Within these networks, different kinds of relationships have different effects. Whereas relationships with strong social ties are very efficient routes for spreading information, relationships that are characterized by weaker ties may be more valuable in providing new information that individuals would not typically receive from closer relationships.¹⁵⁴ Peer networks have been shown to influence physicians with regard to practice patterns, new medication adoption, and technology use.¹⁵⁵ Social network theory has been applied by a number of authors in examining physician adoption, and Rogers is heavily cited in this literature.¹⁵⁶ Rogers has proposed five categories of adopters: innovators, who tend to embrace new ideas and have higher appetites for risk; early adopters; the early majority; the late majority; and laggards.

Economics Literature. Economic models may be either macroeconomic or microeconomic in nature. Macroeconomic models describe industrywide or economywide phenomena and are less suited to a task in which we seek to understand and influence the behaviors of individual physicians. The macroeconomic models specify aggregate functions that can be parameterized to yield S-shaped technology diffusion curves. In these models, the aggregate diffusion curves are not derived by aggregating individual adoption curves.

In contrast, microeconomic models focus on individual firm behavior and capture the influence of various factors and their impact on the firm's decision to adopt. Microeconomic theories of technology adoption cite a broad range of influences, including rank effects that are nonmodifiable attributes of a firm, such as size, ownership structure, and location;¹⁵⁷ stock effects or the extent to which a given technology has diffused, and the competitive advantage that adoption confers at that level of diffusion;¹⁵⁸ and cumulative learning, or the impact of incremental knowledge acquisition on the adoption decision.¹⁵⁹ More recent models of technology diffusion and adoption have been based on theories of investment under uncertainty.^{160,161} These models capture the role of uncertainty and expectations of costs and benefits in technology adoption, as well as the role information plays in reducing uncertainty.¹⁶²

1.3 Overview of Findings from Site Visits

To complement our review of the literature, we conducted telephone interviews and site visits with eight small practices. The purpose of these site visits was to:

- ▶ Explore hypotheses generated by the literature review
- ▶ Validate elements in the preliminary economic framework.

We developed a list of sites based on recommendations from the Technical Expert Panel (TEP) established for this study, and Booz Allen subject matter experts. Sites were chosen to ensure representation of a diverse set of characteristics, including size, geographic location, specialty, age, ownership, adoption status, and willingness to participate. The criteria for site selection were based on factors identified in the literature as relevant to adoption. We conducted telephone interviews with all eight sites, followed by an in-person visit to a sub-sample of five practices. Site interviews and visits were conducted by a two-person team using structured interview guides. Areas of discussion related to practice demographics, EMR research and selection, EMR system characteristics, costs and benefits, and post-implementation observations.

EMR adoption was motivated by a number of factors that could be mapped to either improvements in quality, improvements in income, or enhancements to physician quality of life. In all the sites, information acquisition played a critical role in the process of researching and selecting an EMR. Practices universally obtained information from several sources, including the Internet, attendance at conferences and trade shows, recommendations from professional societies such as AAFP, and visits to other practices. Peer influences played a significant role in influencing choice of vendor and functionality. Practices evaluated multiple vendors prior to selection.

The five practices we visited had implemented EMR systems that shared certain common functionalities, including the following:

- ▶ Scheduling
- ▶ Documentation
- ▶ Order entry (although level of sophistication varied)
- ▶ Patient history
- ▶ Report generation
- ▶ Basic decision support.

Practices incurred costs between \$15,000 and \$80,000, which in some cases included practice management software. Differences in costs reflect variations in functionality, the purchase of practice management software, and a practice's ability to negotiate prices with vendors.

In addition to negotiation skills, our site visits revealed another factor that may significantly influence the cost associated with adoption. Most of the practices we visited were led by a physician champion with considerable computer or EMR experience. This contribution of "human capital" to the practice lowered the costs of information acquisition, reduced uncertainty, and contributed to a smoother implementation process. The only practice that did not have this expertise committed costly errors and ultimately had to hire an information technology consultant.

All practices reported productivity losses during the first 3 to 6 months of adoption. Practices also reported accruing financial benefits, including cost savings from reduced chart room storage, elimination of transcription costs, and reductions in malpractice rates; and increases in revenue through improved coding and charge capture. They were, however, unable to quantify these benefits in a systematic manner. Non-financial benefits included improvements in quality of care, workflow efficiencies, and enhancements to the physicians' quality of life.

The site visits confirmed several of the hypotheses that we generated from the review of the literature. In addition, these visits provided a key insight into the role of human capital in reducing the true costs associated with adoption.

1.4 Proposed Economic Framework for EMR Adoption

The literature review and site visit findings revealed key factors relevant to physician adoption decisions:

- ▶ Physician motivators for adoption—income, patient safety/quality, and leisure
- ▶ Variations in EMR functionality

- ▶ EMR costs and benefits
- ▶ Role of human capital
- ▶ Role of uncertainty
- ▶ Importance of information.

Using microeconomic technology diffusion modeling approaches from the economics literature, we constructed an economic framework that combines these factors in a structured manner. Our choice of modeling approach was determined by the primary purpose of this project and by the ability of microeconomic approaches to incorporate factors such as peer networks and their influence on adoption. Having selected a microeconomic approach, we specified the elements of an economic framework.

The proposed economic framework describes adoption decisions at the small practice level. For the purposes of this study, we define small practices to include a maximum of nine physicians. This is consistent with the specification from the survey literature.^{163,164}

Our proposed economic framework consists of the following elements:

1.4.1 Unit of Decision-Making

We specify the unit of decision making as the physician entity, who acts as if he or she were a sole decision-maker. Although this represents an abstraction from real-world decision making, data from the literature review and the site visits do not emphasize the role of intrapractice decision-making processes as being a significant factor in EMR adoption. Our framework, therefore, focuses on the adoption of technology as an economic process and does not explore the political economy of decision making in small offices.

1.4.2 Physician entity's preferences

The physician entity has preferences over income, leisure, and patient safety. These preferences influence adoption and are represented mathematically by a utility function.

1.4.3 Characterization of technology

In our framework, EMRs are characterized as a series of values z_1, \dots, z_n that coincide with varying levels of functionality. Any existing technology used by the physician entity is characterized as z_0 . The specification of the technology here is similar to the concept of quality ladders used by Grossman and Helpman (1991).¹⁶⁵ The EMR technology z can assume a series of discrete values where higher levels of z represent higher levels of functionality. This specification was designed to capture the widespread heterogeneity in the definition of EMRs and the various manifestations of its functionality.

1.4.4 Choice variables of physician entity

The physician entity chooses physician and nonphysician labor, time spent on researching EMRs, and the technology z to maximize its preferences. The choice of physician labor and technology z affects income, leisure, and medical errors. The physician entity can choose not to adopt an EMR, but rather to use the existing technology z_0 (i.e., paper).

1.4.5 Revenue function and uncertainty associated with EMRs impact on revenue

Using the various inputs (labor, staff, and technology z), the physician entity provides patient care that generates revenue. Our specification of revenue allows representation of a variety of reimbursement mechanisms, including fee-for-service and capitation. Adoption of EMR can lead to increases in revenue through improved charge capture or increases in patient volume. However, the impact of EMRs on the physician entity's revenue is uncertain. The physician entity has expectations or beliefs about the impact of EMRs on revenue. These expectations or beliefs evolve during each time period based on new information that the physician entity acquires. This updating of expectations depends on the amount of time a physician entity chooses to spend on this process and the number of other physician entities that are EMR adopters. This specification accounts for the costs involved in accumulating information on EMRs and the role that peer adopters play in enhancing the information set of a nonadopter.

1.4.6 Cost function and uncertainty associated with EMRs impact on costs

The physician entity incurs costs in providing patient care. Costs associated with care delivery include physician and non-physician labor costs, and non-labor costs such as equipment, supplies, and rent. If the entity chooses to adopt an EMR, it will also incur the acquisition and recurring costs associated with the new technology. These acquisition and recurring costs depend on the physician entity's existing knowledge about EMRs and complex information technologies. Adoption of EMRs can have an impact on the costs of the entity. Similar to benefits, cost impacts are uncertain. Information about the cost impact of EMRs can help lower this uncertainty. The physician entity's stock of information depends on the time allocated to gather the information and the number of existing adopters.

1.5 Approach to Framework Validation

The framework represents a high-level theoretical specification of the variables relevant to adoption and their interrelationships. To be useful from a policy perspective, it will be necessary to validate the framework and test its ability to explain and possibly predict adoption rates among small practices. To validate the framework and understand the quantitative impact that specific variables have on adoption, it will be necessary to obtain data at the small practice level. In reviewing the literature, we found no data sources in the public domain that can be used to validate the framework. As part of this study, we developed a strategy to validate the proposed economic framework.

Although the proposed economic framework appears simple, actual computation and validation of this framework involves solving a multi-period nonlinear optimization problem that is fairly complex. There are three major phases in the validation of the framework:

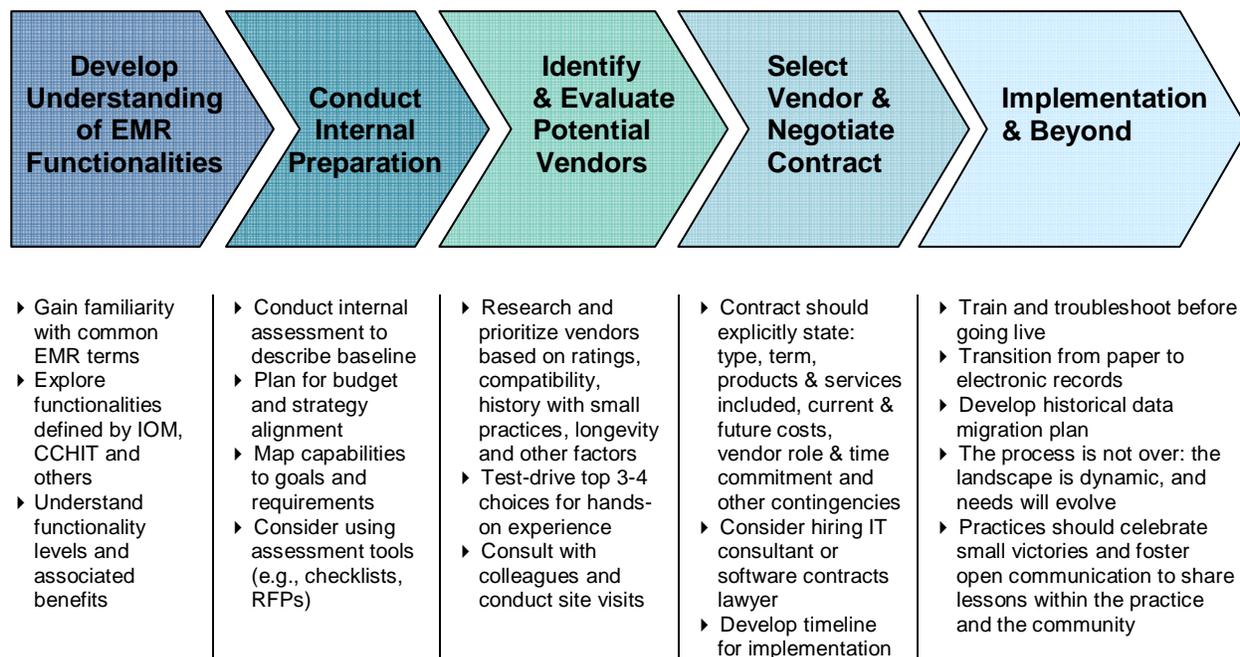
- ▶ Phase One involves evolution of the framework into a model through detailed mathematical specification.
- ▶ Phase Two entails collection of data that can be used to validate the model.
- ▶ Phase Three involves model estimation and validation.

The successful execution of these options depends on the availability of data. Collection of primary data, whether in the near or medium term, will be critical to the utility of the economic model for understanding adoption and exploring relevant policy options. Data collection could occur *de novo* or could be performed through partnerships with existing surveys. It would be important to consider the time and cost implications of these alternative data collection options and select the most cost-effective approach in the near term. Any decisions that limit the scope of the data collection effort will have significant implications for model computation and validation.

1.6 EMR Implementation Roadmap

The EMR landscape can be complex and intimidating to those unfamiliar with it. Based on the literature review and findings from the site visits, we developed an EMR implementation roadmap. The roadmap was designed to serve as a practical guide for small practices (of one to nine physicians) contemplating EMR adoption. It provides information on the major steps in the process of adopting and implementing an EMR. For each of the steps in this process, we discuss specific activities that practices need to undertake for successful implementation. We recommend that practices supplement the information in the roadmap with in-depth research on each of these steps from alternative sources. Exhibit 5 describes the steps and activities for a practice considering adoption.

Exhibit 5. Steps for Practices Considering EMR Adoption



1.7 Summary and Conclusion

Our study has resulted in the development of a microeconomic framework that captures the key factors relevant to EMR adoption. These factors include physician preferences or motivators of adoption, valuation of EMR costs and benefits, uncertainty associated with these costs and benefits, and the important role that information plays in lowering the uncertainty. The framework can be evolved into a fully specified economic model that can be computed using large-scale data. Such a computed model will yield individual practice-level adoption curves that can be aggregated to obtain industry-level EMR adoption curves. In addition, the model will shed light on the relative significance of various factors affecting adoption and the magnitude of their impacts.

In reviewing the literature on EMR adoption, we have also identified certain limitations with existing studies. These limitations extend to the survey and EMR cost-benefit literature. There is a lack of a standardized survey of practices that can be used to observe adoption rates over time and examine changes in factors affecting adoption. Recent initiatives by ONC in the area of survey development will help address this gap. In addition to the survey literature, we believe that there is a significant void with respect to robust data-driven studies of EMR costs and benefits. Most of the existing studies are based on projection models and not on empirical data collection from existing practices. There is a paucity of well-designed large-scale prospective or retrospective evaluations of the costs and benefits associated with ambulatory EMRs. Absence of such robust EMR cost-benefit evidence can contribute to physician uncertainty and serve as a deterrent to adoption.

2.0 Introduction

Electronic Medical Records (EMRs)ⁱⁱⁱ are increasingly viewed as a means for achieving improved health care quality and reduced costs. In 2004, President Bush announced a ten-year goal of making EMRs available to most Americans. To help achieve this goal, he issued an Executive Order that established the Office of the National Coordinator for Health Information Technology (ONC).¹⁶⁶ The Executive Order also emphasized the importance of:

- ▶ Establishing evidence on costs, benefits and outcomes associated with HIT implementation; and
- ▶ Reducing the risks that providers face in making HIT investments.

In addition to the Executive Order and the establishment of ONC, there have been a number of public and private sector initiatives focused on promoting the adoption of HIT. These include community focused initiatives such as those funded by Agency for Healthcare Research and Quality (AHRQ), physician-focused initiatives such as The Doctor's Office Quality-Information Technology (DOQ-IT) program, and standards-focused initiatives such as the establishment of e-prescribing standards under the Medicare Modernization Act (MMA).

Despite these initiatives, the adoption of EMR has been limited and adoption rates vary widely across care settings. Recent surveys suggest that adoption rates in ambulatory settings range between 15-18 percent.^{167,168} This overall rate of adoption masks significant variations among the kinds of functions adopted, and the kinds of practices that are adopting these functions. For example, Burt and Sisk found that practices with greater than 20 physicians have approximately three times the adoption rate of solo practices and twice the adoption rate of practices with fewer than ten physicians.¹⁶⁹

With approximately 75 percent of physician practices employing fewer than nine physicians, such low adoption rates among small practices does not bode well for the national goal of achieving broad EMR diffusion in ten years.¹⁷⁰ Low rates of EMR adoption have been attributed to a variety of forces including misaligned financial incentives, lack of standardization among EMR applications and the high turnover of HIT vendors.¹⁷¹ There are few studies however, that have examined, at a micro-economic level, the various economic and non-economic factors that promote or deter EMR adoption in small practice settings. Understanding these factors and their relative importance to EMR adoption would be critical for establishing policies that can promote adoption.

To provide a deeper understanding of the factors that impede or impel EMR adoption, The Office of the Assistant Secretary for Planning and Evaluation (ASPE) in the Department of Health and Human Services (HHS) recently engaged Moshman Associates and Booz Allen Hamilton to assess the economics of EMR adoption and implementation in physician small

ⁱⁱⁱ The reader should note that while there are a variety of terms that are often used interchangeably such as EMR (electronic medical record) or EHR (electronic health record), we have used the term EMR throughout the report, unless citing the work of other authors who may have used alternative terminology.

practice settings. This study, which was originally envisioned as a two-phased approach, has been focused primarily on the following:

- ▶ Understanding the factors that influence EMR adoption in small practices
- ▶ Developing a micro-economic framework that incorporates these factors

This framework can serve as the foundation for a formal micro-economic model in a second phase of analysis. Using appropriate data, this microeconomic model can be estimated to derive individual practice EMR adoption curves that can be aggregated to derive industry-level adoption curves. The model can also be used to examine the relative importance of factors affecting EMR adoption and the magnitude of that impact.

The rest of this report is organized as follows:

- ▶ Chapter 3 – Study Methodology
- ▶ Chapter 4 – Literature Review
- ▶ Chapter 5 – Discussion of the Literature
- ▶ Chapter 6 – Site Visit Summary
- ▶ Chapter 7 – Economic Framework for EMR Adoption
- ▶ Chapter 8 – Mapping of Framework to the literature
- ▶ Chapter 9 – Approach to Validation of Preliminary Framework
- ▶ Chapter 10 – EMR Implementation Roadmap, and
- ▶ Chapter 11 – Conclusion.

3.0 Study Methodology

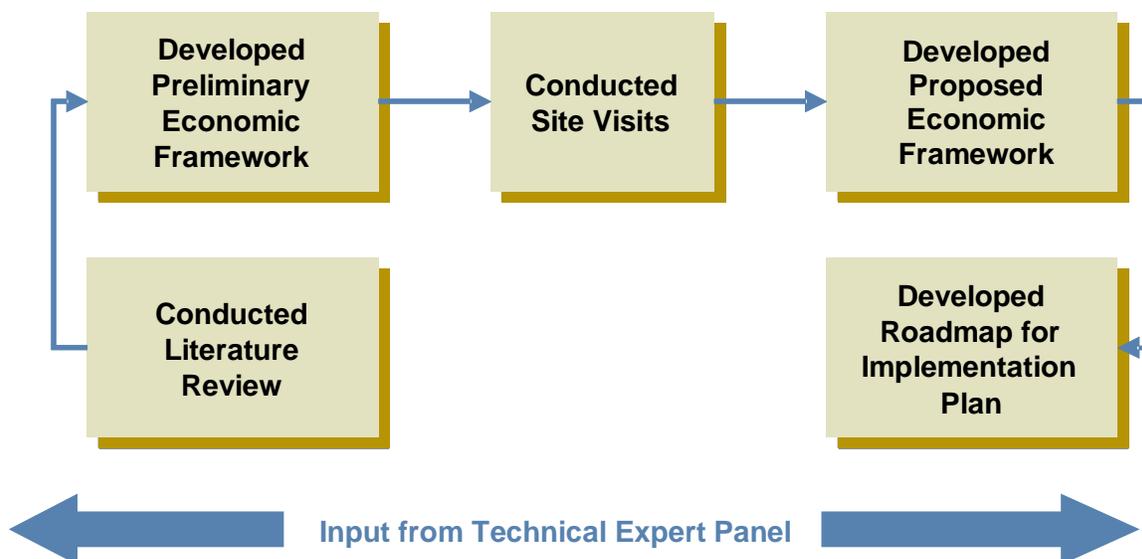
In this chapter we discuss our overall methodology to developing a microeconomic framework for EMR adoption. Our approach was iterative and consisted of three main elements:

- ▶ Evidence gathered from peer-reviewed and grey literature
- ▶ Primary data collected through site visits
- ▶ Input obtained from a Technical Expert Panel (TEP)

3.1 Established Technical Expert Panel

As part of this project, we were required by ASPE to establish a TEP. The role of the TEP was to provide guidance and feedback throughout the duration of this project and specifically to participate in discussions and review interim reports. TEP members were chosen to ensure a diversity of perspective. The TEP included health care economists, electronic medical record (EMR) vendors, physicians, EMR consultants, and a human factors researcher bringing a rich and diverse perspective to this project. The TEP played a significant role in providing guidance and in reviewing all of the chapters contained in the report.

Exhibit 6. Study Methodology



The exhibit above shows the steps in our methodology. We describe each of these steps briefly below and provide additional detail in subsequent relevant chapter of the report.

3.2 Conducted Literature Review

We conducted an in-depth review of the peer-reviewed and grey^{iv} literature using a structured and systematic process. To ensure that we captured the factors relevant to the economic framework we used a multi-pronged approach to ensure inclusion of articles germane to this study.

3.2.1 Identified Literature Review Domains

The first step in the literature review was to identify the articles relevant to this project. To help identify these articles, we divided the literature review into the domains described below. The first five domains focused on various aspects of EMR and its adoption, and the sixth domain focused on models of technology adoption and diffusion.

- ▶ EMR Definition and Functionality—We focused on the literature that defines and characterizes EMR functionality. We drew on a variety of sources, including the Institute of Medicine (IOM), the Healthcare Information and Management Systems Society (HIMSS), and Gartner.
- ▶ EMR and its impact on IOM’s six aims of quality – We examined the literature on the impact of EMR on safety, effectiveness, and efficiency in ambulatory and inpatient settings.
- ▶ EMR Cost-Benefit and Return on Investment (ROI) —We focused on the literature related to EMR costs, benefits, and ROI.
- ▶ EMR adoption—We focused on literature that identified factors affecting physician adoption of EMRs. Our intent was to gain an understanding of the characteristics and motivations of adopters and non-adopters.
- ▶ EMR initiatives—We focused on current EMR initiatives including an overview of notable programs and the means by which they seek to influence adoption.
- ▶ Technology adoption models—We identified articles on models of technology diffusion and adoption from the sociology and economics literature.

3.2.2 Performed Review of Literature

For each of the domains discussed above, we followed a standardized and uniform process for the literature review. We first conducted key word searches to identify the relevant articles in each of these domains. A variety of search engines and journal databases, including PubMed, MedLine, Cochrane, Econlit, Google, and Google Scholar, were used to identify a broad spectrum of articles relevant to EMR adoption in physician offices. Initial keywords included, but were not limited to, physician EMR adoption, health information technology (HIT) adoption,

^{iv} Grey literature refers to publications produced by government, academia, business, or industry. It includes reports, conference proceedings, working papers, government documents, and other literature that have not been published in a peer-reviewed journal.

technology diffusion, EMR costs and benefits, EMR and safety, errors, adverse drug events (ADE), and efficiency. Articles that were electronically linked to initially identified articles in databases were also reviewed. Bibliographies from multiple articles were also reviewed to identify other relevant publications. We also reviewed articles suggested by the TEP.

We identified and reviewed over 350 potentially relevant articles and reports. Articles were evaluated based on their temporal and topical relevance as well as the quality of the research methods. Those deemed relevant were captured in a tracking tool and assigned to team members for review. We then created narrative synopses of the most relevant articles for incorporation into the literature review chapters and for the framework. Of the approximately 350 articles reviewed and assessed, about 189 articles are cited in this report.

Upon completion of the review, we analyzed the major findings from the literature and identified key factors that we believed were relevant to physician adoption. The findings from the literature resulted in the generation of certain hypotheses that we explored through visits to physician practices. The key themes that emerged from the literature and the associated hypotheses are discussed in Chapter 5.0.

3.3 Developed Preliminary Economic Framework

Our review and analysis of the literature on EMR adoption and technology diffusion informed the development of our preliminary economic framework and its associated elements. We examined alternative approaches to developing a framework including system dynamics, agent-based approaches, social network theory, and microeconomic approaches. We focused specifically on microeconomic models of technology adoption because one of the major objectives of our study was to develop a microeconomic framework for EMR adoption.

Based on our analysis of these different modeling approaches and our review of the literature, we developed a preliminary framework using a microeconomic modeling approach to physician EMR adoption. We discuss the rationale for the choice of this modeling approach in greater detail in Chapter 7.0. In addition to the framework we created an initial mapping between the framework elements and the literature.

3.4 Conducted Site Visits

The next step of our approach involved primary data collection from physicians to help validate our hypotheses and the elements of the preliminary economic framework. Our site visit methodology consisted of the following steps:

Identified Sites for Primary Data Collection

We first identified a list of sites for the primary data collection effort. The sites were identified through our literature review, as well as through dialogue with organizations such as American Academy of Family Physicians (AAFP), the TEP, and recommendations from other Booz Allen subject matter experts. After we gathered information on potential sites, we created a tracking

sheet containing information on each practice, including size, specialty, geographic location, adoption status, and willingness to participate in the site visit. We identified a variety of practices at various stages in the adoption process. We presented an initial list of selected sites to ASPE and the TEP, accompanied with justifications for selection. The final list of sites was determined through discussions with ASPE and the TEP, and based on the sites' willingness to participate. We interviewed/visited eight sites stratified by size, location, and specialty. We interviewed adopters as well as physicians who have contemplated adoption but have yet to implement an EMR.

Developed Interview Guide

To facilitate collection of data from the sites, we developed an interview guide that was informed by the preliminary framework and associated elements. The purpose of the guide was to provide structure to the discussions and to ensure that key topic areas were addressed. The discussion guide also ensured a level of standardization in the data collection effort. After proposing an initial list of questions, we finalized the discussion guide through consultations with ASPE and the TEP. The guide was divided into two sections one section was used for site visits and another for telephone interviews.

Collected and Analyzed Data

Based on guidance from ASPE and the TEP we conducted our site visits in two stages. The first stage was a telephone interview, and the second stage was an in-person site visit. Using the finalized list of selected sites, we scheduled the visits and telephone interviews. A two-person team interviewed/visited each site. The duration of each of the telephone interviews was an hour and the site visit about 3 hours. The team met the practice staff but focused on interacting with the physician "champion" or office manager responsible for leading the EMR purchase and implementation. After the visits and interviews were completed, we compiled and analyzed data to extract common themes around EMR adoption.

Discussed Findings

After completion of the data analysis, we discussed the findings with ASPE and the TEP. The findings highlighted the factors that determine adoption/non-adoption of EMRs.

3.5 Developed Proposed Economic Framework and Validation Strategy

Based on the data gathered from the site visits and the major themes that emerged from these visits, we updated the elements in the preliminary framework to create the proposed microeconomic framework for EMR adoption. We also expanded the initial mapping of framework elements to the literature to include the data gathered from the site visits.

In addition to updating the framework, we developed a strategy to validate the framework. This strategy provides a roadmap to:

- ▶ Evolve the framework into a model through detailed mathematical specification

- ▶ Collect data that can be used to validate the model
- ▶ Estimate and validate model.

The approach to validating the framework was developed using our knowledge of standard techniques used in economics as well as input from the TEP. The proposed economic framework, mapping of framework elements, and the validation approach are discussed in Chapters 7.0, 8.0 and 9.0, respectively.

3.6 Developed EMR Implementation Roadmap for Physician Offices

Based on the data gathered from the literature review and site visits we developed roadmap for physicians contemplating EMR adoption. The guide is designed to assist physicians through the various phases of EMR adoption. Although the guide provides useful information, physicians considering adoption should research and seek information on implementation from other sources.

4.0 Literature Review

4.1 Introduction to the Literature Review

As described in Chapter 3.0 we examined the peer-reviewed and “grey” literature to identify a variety of characteristics and behaviors that are associated with physician adoption and implementation of electronic medical records (EMR) in the ambulatory environment. We also identified relevant models of technology diffusion, and initiatives to promote EMR adoption and implementation. This information, augmented by site visits to physician offices, was used to construct an economic framework that describes a set of factors that may explain physician adoption and implementation of EMRs in the ambulatory environment.

In this chapter we describe the findings from the literature review. The review is divided into seven sub-sections which are described in brief below:

EMR System Characteristics

A single universally accepted definition of an EMR has not been established in the literature.¹⁷² However, the level of functionality of an EMR will have direct relevance to the costs of the product and the benefits it yields. A number of sources in the literature have grouped functionality in three to five categories.^{173,174,175} EMR functionality ranges on a continuum from view-only capability of basic clinical information, to e-prescribing with various levels of sophistication and decision support, to robust drug and test order entry that includes more advanced decision support. Systems vary not only by functionality but by usability. Surveys and the technology diffusion literature suggest that the complexity of these levels of functional capability can impose significant time and cost burdens on physicians who are choosing vendors and deciding on which permutation of functional capabilities are optimal for their practice.

Given these variations in EMR functionality and definitions, it is important to examine this literature for the following reasons:

- ▶ Ensure appropriate characterizations of EMR technology in developing an economic framework and ultimately a model
- ▶ Correlate different functionalities with costs, benefits, and net benefits
- ▶ Examine differential impact of various functionalities on adoption, and correlate functionalities with practice characteristics

HIT and Health Care Quality Improvement

In this chapter we present evidence that EMRs and computerized physician order entry (CPOE) can improve the quality of care. We focus in particular on the evidence relevant to the notion that these tools improve patient safety, promote evidence-based care, and increase cost efficiency. Though the quality of the studies and the strength of the evidence vary significantly, a brief overview of this literature is relevant for a number of reasons. First, we review the classic articles on the relationship or potential impact between HIT and medical errors, adverse events, and

patient safety. This review provides a useful foundation for those unfamiliar with this literature. Second, the literature on quality of care may influence the perspective of physicians regarding the benefits of HIT, and depending on how one interprets the evidence, it may either persuade or dissuade adoption. Third, the benefits, particularly the quantifiable benefits related to efficiency and cost cited in this body of literature, have been used by subsequent investigators to help quantify the costs, benefits, and net benefits of EMRs and CPOE.

Return on Investment of EMR Adoption

In addition to the qualitative and quantitative benefits of HIT adoption, in this chapter we also examine the costs, benefits, and return on investment (ROI) associated with EMR adoption. We have focused our review of the literature on studies with temporal as well as topical relevance; studies published prior to 1999 have not been included in this section. This literature is dominated by projection models rather than empirical measurement of the costs and benefits of actual EMR implementations.^{176,177,178,179} Of the eight ROI studies we identified in the peer-reviewed literature, only one study used retrospective empirical data to estimate the ROI in the small office setting.¹⁸⁰ The ROI projection models in the peer-reviewed literature rely heavily on the benefits literature described above as well as on expert opinion. This literature is highly relevant as cost and net financial benefit are primary concerns of physician adopters and are thus very pertinent to an economic framework of EMR adoption.¹⁸¹

Practice and Physician Characteristics that Influence EMR Adoption

In creating an economic framework of EMR adoption, it is critical to capture physician and practice characteristics that correlate with adoption. Here the physician survey literature proved to be invaluable. Though methodologically sound surveys relevant to physician EMR adoption are limited, surveys by Audet,¹⁸² Gans,¹⁸³ and Burt and Sisk¹⁸⁴ are heavily cited. In addition, surveys conducted by the American Academy of Family Physicians^{185,186,187,188} and the Medical Records Institute¹⁸⁹ were also useful. The practice characteristics discussed include: size, ownership and compensation structures, location, and specialty. Physician characteristics discussed include: gender, age, and medical specialty. Many of the relevant practice and physician characteristics such as size, ownership structure, and specialty are not modifiable and cannot be directly influenced by policymakers seeking to accelerate adoption. However, there are often factors underlying these characteristics that may provide insight relevant to decision-makers.

Physician Perspectives on EMR Benefits and Barriers to Adoption

Objective assessments of cost and benefit are important; however, the current evidence is limited in both methods and number of studies. Ultimately, beliefs and expectations regarding costs and benefits drive individual purchase decisions and are relevant to an economic framework that describes adoption behavior. These expectations may be influenced by published evidence, but they are also likely to be strongly influenced by peer networks.^{190,191} For policymakers, it is important to understand these perspectives when seeking to influence physician adoption behavior. The survey literature, in particular, provides insights into physician attitudes towards EMR adoption.

Technology Diffusion Literature

The technology diffusion literature describes, from a theoretical perspective, the mechanisms by which new technologies proliferate as well as the barriers that may impede their proliferation. We have focused on two intellectual disciplines that dominate this literature: sociology and economics. These models will provide the theoretical underpinnings for the construction of an economic framework of physician adoption of EMRs, a principal objective of this project. We will describe this literature in somewhat more detail here as it is a useful lens through which to examine the rest of the literature review.

Sociology Literature. The sociology literature emphasizes the importance of interpersonal relationships and social networks in diffusing information that influences adoption decisions. Within these networks, different kinds of relationships have different effects. Whereas relationships with strong social ties are very efficient routes for spreading information, relationships that are characterized by weaker ties may be more valuable in providing new information that individuals would not typically receive from closer relationships.¹⁹² Peer networks have been shown to influence physicians with regard to practice patterns, new medication adoption, and technology use.^{193,194} Social network theory has been applied by a number of authors in examining physician adoption, and Rogers is heavily cited in this literature.¹⁹⁵ Rogers has proposed five categories of adopters: innovators who tend to embrace new ideas and have higher appetites for risk, early adopters, the early majority, the late majority, and laggards.

Economics Literature. Economic models may be either macroeconomic or microeconomic in nature. Macroeconomic models describe industry-wide or economy-wide phenomena and are less suited to a task in which we seek to understand and influence the behaviors of individual physicians. The macroeconomic models specify aggregate functions that can be parameterized to yield S-shaped technology diffusion curves. In these models, the aggregate diffusion curves are not derived by aggregating individual adoption curves.

In contrast, microeconomic models focus on individual firm behavior and capture the influence of various factors and their impact on the firm's decision to adopt. Microeconomic theories of technology adoption cite a broad range of influences, including: rank effects that are non-modifiable attributes of a firm, such as size, ownership structure, and location;¹⁹⁶ stock effects or the extent to which a given technology has diffused, and the competitive advantage that adoption confers at that level of diffusion;¹⁹⁷ and cumulative learning, or the impact of incremental knowledge acquisition on the adoption decision.¹⁹⁸ More recent models of technology diffusion and adoption have been based on theories of investment under uncertainty.^{199,200} These models capture the role of uncertainty and expectations of costs and benefits in technology adoption as well as the role information plays in reducing uncertainty.²⁰¹

Current EMR Initiatives

The government, professional organizations, foundations, and others have initiated programs to stimulate the adoption of HIT, especially EMRs, e-prescribing, CPOE, and electronic data exchange. These programs often include some aspect of financial support, information and

training, or infrastructure support, such as programs to facilitate standards development and harmonization. Not all of these programs are directly aimed at small physician practices; however, they are all worthy of note for the ways in which they attempt to affect various care delivery settings. These programs are discussed in detail in Chapter 4.8. These programs provide useful insight into not only what has been done but what might be done in the future. We provide an overview of notable programs and the means by which they seek to influence adoption.

Summary

The purpose of the literature review was to provide an evidence-based foundation for the development of an economic framework that describes the factors that influence physician adoption of EMRs. Each of the categories described contribute to that foundation in different ways, including the influence of quality, costs, benefits, practice and physician characteristics, physician attitudes, technology attributes, and various programs to support HIT. Models from the technology diffusion literature provide a construct within which to integrate these disparate influences. The framework we have proposed is based on a microeconomic approach but is influenced by other disciplines and considerations. Each element in the economic framework has been mapped to an evidence-based source in the literature.

4.2 EMR System Characteristics

In order to identify the drivers of EMR adoption by physician small practices, it is important to understand what is meant by the term electronic medical record. One of the major challenges facing both the industry and those who study it is the multiple definitions, specifications, and functional capabilities that are aligned with the term. Without a common taxonomy, it will be difficult to unravel the forces that motivate or impede physicians from selecting, implementing, and using an EMR. In this section we present definitions of EMR and related terms that have been promulgated by leaders and leadership organizations that have national influence. In addition to theoretical discussions of EMRs and related functionality, we also examined the definitions and functionality that were derived empirically from the survey literature.

A number of leadership organizations including the Institute of Medicine (IOM) and the Health Information Management and Systems Society (HIMSS) have offered broad definitions of EMR. Abbreviated versions of HIMSS and IOM definitions are provided in Exhibit 7.

Exhibit 7. EHR Models

HIMSS EHR Definitional Model, Version 1.1	IOM, 2005 (derived from HL7 EHR Functional Model DTSU)
<ul style="list-style-type: none"> • A secure, real-time, point-of-care, patient-centric information resource for clinicians • Provides access to patient health recorded information where and when they need it • Automates and streamlines the clinician’s workflow, closing loops in communication • Supports the collection of data for uses other than clinical care, such as billing, quality management, and public health diseases 	<ul style="list-style-type: none"> • A longitudinal collection of electronic health information • Provides immediate electronic access to person- and population-level information by authorized users • Provides knowledge and decision support to enhance the quality, safety, and efficiency of care • Supports efficient processes for the delivery of health care

Although these definitions may be broad enough to help develop consensus around high-level functional capability, they are not sufficiently specific to allow comparison between the costs and benefits of different technology choices that physicians may make. There is significant variation in EMR applications used to achieve the functional objectives cited in these definitions. Likewise there is significant variation in usability, a critical factor in physician adoption, which is generally not described or addressed in the literature.

In addition to multiple definitions of EMR, there are multiple terms and acronyms (EHR, CPR, etc.) used to describe similar EMR technologies. In 2003, Brailer and Terasawa cited 13 different terms used to refer to the functions frequently associated with an EHR.²⁰² This variability not only creates confusion in discourse, but can complicate systematic efforts to study rates and drivers of adoption. For instance, it becomes difficult to estimate how many physicians currently use EMRs if different terms are used to describe the application and the functions it performs. Surveys that probe through a simple query, such as “Do you currently use an EHR (or CPR or EMR)?” may produce misleading results. EMR systems that provide the ability to only view laboratory results or to capture clinical notes are considered equivalent to those systems that include clinical data management capabilities such as decision support, order entry and e-prescribing. The fundamental difference directly impacts clinical outcomes. In this example, “view only” allows a physician to see the patient’s previous health record, but it does not facilitate current health data management, such as adding an adverse reaction to the patient’s medical record. An international survey of EMR adoption suggested that many countries had adoption rates approaching 80 percent.²⁰³ However it is unclear in this case exactly *what* is being adopted and whether the authors are comparing equivalent systems with equivalent functionalities.

In attempting to define drivers of adoption, it will also be important to define *what* is being adopted. In an effort to define what physicians are adopting and what impels or impedes them in the process of adoption, it is reasonable to employ a functional approach to crafting definitions. In this section we describe some of the functional models used to describe EMRs, as developed by leadership organizations of national influence, such as the IOM, the Health Level 7 (HL7) EHR Technical Committee, and the Gartner Group.

4.2.1 IOM Functional Model

The IOM constructed a functional model with the purpose of developing a common set of requirements for capabilities of EMR systems. The IOM used the following five criteria to collectively identify eight core functions in any EHR system.²⁰⁴

- ▶ Improve patient safety—prevent harm to patients
- ▶ Support the delivery of effective patient care—evidenced-based medicine
- ▶ Facilitate management of chronic conditions—yield better outcomes and mitigate costs
- ▶ Improve efficiency—reduce unnecessary expenditures
- ▶ Feasibility of implementation—promote willingness to adopt and utilize new technologies

These criteria in turn were used to define eight functional capabilities that an EHR should include (see Exhibit 8).

Exhibit 8. IOM's Eight Core EHR Functionalities²⁰⁵

Functionality	Description
1. Health Information and Data	EHR systems with defined capabilities include features such as medication lists, allergy lists, patient demographics, clinical narratives, laboratory and other diagnostic test results, and medical diagnoses.
2. Results Management	Electronic results can significantly benefit providers in the management of all types of results, including laboratory, radiology, and various other procedures. This capability gives providers enhanced access to information that enables them to make quicker treatment decisions.
3. Order Entry/ Management	CPOEs can significantly improve operating processes in several ways such as eliminating duplicative and ambiguous orders and in some instances automatically generating orders. This results in time savings for both the patient and provider.
4. Decision Support	Such systems may support medication prescription (dosing and drug selection), diagnosis, and detection of adverse events. Increasingly, decision support systems are being used in disease treatment and management, improving adherence to established evidence-based guidelines.
5. Electronic Communication and Connectivity	The benefits of this functionality are particularly relevant to those patients that access the health care system in various settings, such as patients with chronic disease, who require well-coordinated plans of care.
6. Patient Support	Applications that enable patients to have greater participation in their own care are important. Patient education has demonstrated significant effectiveness in improving control of chronic illnesses. ²⁰⁶
7. Administrative Processes	Electronic billing and coding is a function that is not only more timely but also reassures providers that coding levels are maximized and reduces the fear of fraud and abuse associated with coding. Similarly, insurance verification can be processed at the point of service, which not only reduces administrative burdens but also allows patients to maximize their health care benefits.
8. Reporting and Population Health Management	Without computerized functionalities, many clinical quality indicators, which are the keystone for clinical quality improvement, must be derived from data extracted from many sources (claims data, etc.), which is burdensome and time intensive. EHRs allow a readily available and standardized process to capture clinical outcomes, which in turn can result in improved clinical quality. Reporting capabilities are also enhanced, such as disease surveillance and other mandated indicators.

4.2.2 HL7 EHR System Functional Model

The HL7 EHR System Functional Model was created, based upon the definitions outlined in the IOM report, with the intention of becoming the standard for describing EHR system functionalities in the vendor, provider, regulator, and policy communities.²⁰⁷ The model, endorsed by the HHS as a basis for community discussion and development of standards, is composed of a functional outline and related functional profiles. The functional outline comprises direct care, supportive functions, and information infrastructure. Direct care is defined as functions that provide direct care to one or more persons. Supportive functions are those functions that support management of health services and organizations. Information infrastructure refers to critical functions of security, privacy, interoperability, registry, and vocabulary. This functional model is intended to serve as a compilation of all present and

anticipated EHR system functions. The functional profiles are used to tailor the functions to a specific use. Exhibit 9 displays an overview of the functional outlines.

Exhibit 9. HL7 EHR System Functional Model Functional Outline²⁰⁸

Direct Care	Supportive Functions	Information Infrastructure
<ul style="list-style-type: none"> • Care Management • Clinical Decision Support • Operations Management and Communication 	<ul style="list-style-type: none"> • Clinical Support • Measurement, Analysis, Research, and Reporting • Administrative and Financial 	<ul style="list-style-type: none"> • EHR Security • EHR Information and Records Management • Unique Identity, Registry, and Directory Services • Support for Health Informatics and Terminology Standards • Interoperability • Management of Business Rules • Workflow

4.2.3 Functionalities Described by Brailer and Terasawa

Although the IOM and HL7 functional categories are useful, they are still somewhat broad for the purposes of comparing specific functional characteristics that may drive and differentiate physician motivations to adopt EHRs. Brailer and Terasawa also attempted to develop a functionally-based common taxonomy.²⁰⁹ They studied a spectrum of topologies, each of which was aimed at describing the necessary core functions of EHRs (note: the authors used the term computer based patient record – CPR). These topologies were based on reviews of existing literature and were selected based on the specificity of their definitions. Although there was disagreement as to whether certain functionalities are requisite components of a CPR, Brailer and Terasawa noted that there was agreement in the following categories:

- ▶ Recording information (data capture)
- ▶ Accessing information (data access)
- ▶ Order entry
- ▶ Decision support (practitioner support)
- ▶ Sharing of information and interoperability (communication features)

The authors suggested that computer-based patient record functionalities can be described using the following three perspectives: product features, technical functions, and business processes (see Exhibit 10). They acknowledge that the “business processes” perspective is complicated to understand because of its behavioral orientation; however, they maintain it may be the most beneficial in explaining motivators of HIT adoption. These three “perspectives” are also relevant to models of technology diffusion and adoption which we will discuss in greater depth in another section of this review. However, the extent to which the business intent of the product aligns with the practice’s business intentions and problems will likely be a core factor in determining adoption.

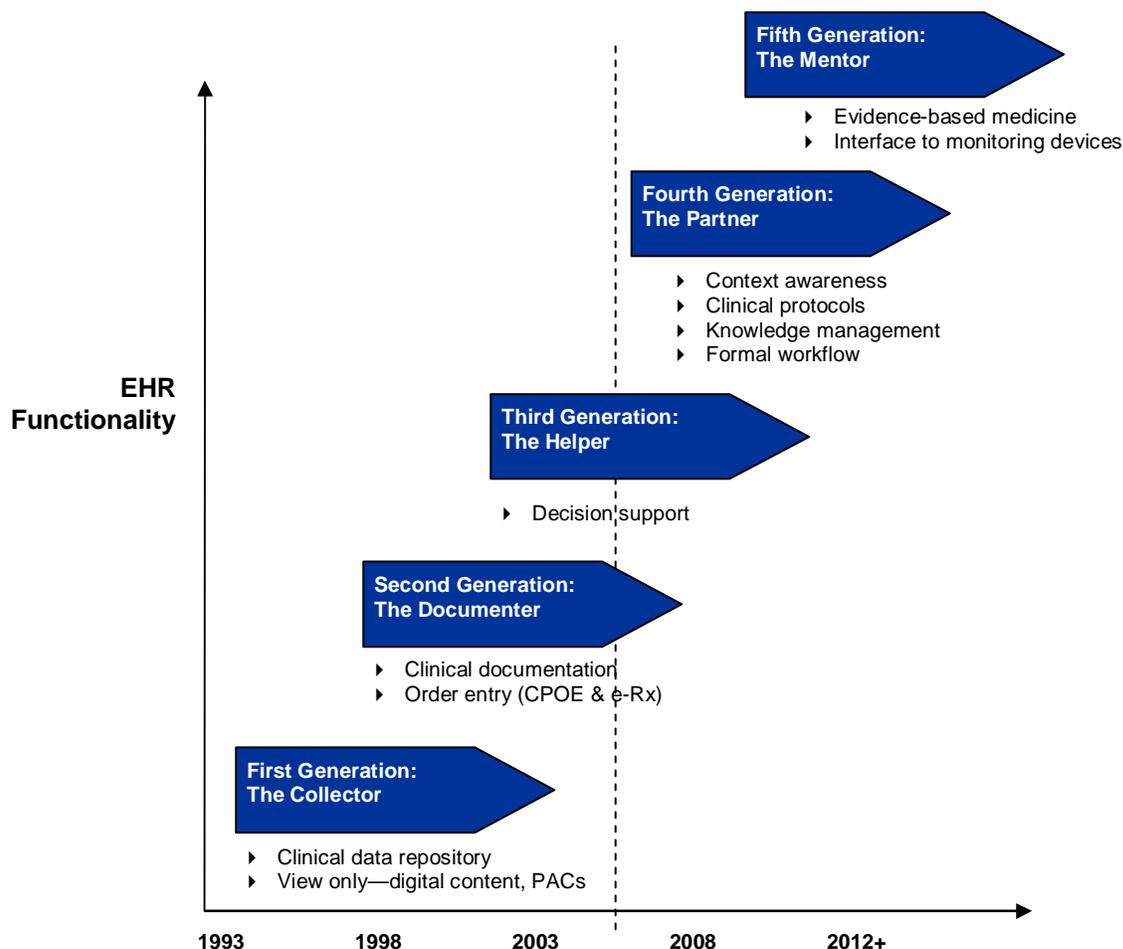
Exhibit 10. Perspectives that Characterize CPR Components

Product Features	Technical Functions	Business Processes
Characterize a product based on WHAT the product does	Characterize a product based on HOW the product functions	Characterize a product based on the BUSINESS INTENT , which is behaviorally influenced. Consequently, this perspective may be highly effective in studying HIT adoption and formulating future direction/policy strategies.

4.2.4 Gartner Generational Model of EHR Functionality

The Gartner Group, an international research and consulting firm dedicated to providing research and analysis to the information technology industry, has created a generational model of EHR functionality. Its model illustrates successively sophisticated levels of EHR functional capability mapped to product features (attributes), technical functions, and business processes, to a limited extent (see Exhibit 11). These levels of functionality are conceptualized as generational with different rates of diffusion. The most basic functions are the most common functions used in actual clinical practice. System architecture and technology platforms may be designed to support multiple generations, with succeeding functionality activated over time.

Exhibit 11. Clinical HIT Stages of Functionality (Gartner)



Hieb has attached estimates of safety benefit to each Gartner-defined generation of capability, suggesting that generations 1 through 5 have the capacity to reduce preventable medical errors by 15 percent, 45 percent, 70 percent, 90 percent, and 100 percent, respectively.²¹⁰ However, it is estimated that currently available products (as of 2005) do not exceed third-generation capabilities, and therefore estimates of benefit relevant to more advanced capabilities (and to some extent current capabilities) are speculative. Although these benefits are speculative, the rapid evolution of EMR technology may cause some to defer adoption decisions for two reasons: concern about obsolescence of current products and a belief that greater ROI may be achievable through EMR technologies available in the near future.

4.2.5 The Certification Commission of Healthcare Information Technology (CCHIT)

The CCHIT is a voluntary private-sector initiative to certify HIT products. CCHIT supports and collaborates with HHS, ONC and AHIC, evolving as necessary to address the dynamic HIT industry. It is comprised of three national HIT leadership associations: HIMSS, the American Health Information Management Association (AHIMA), and the National Alliance for Health Information Technology (Alliance). In November 2005, the Commission published more than 40

functional capabilities for ambulatory EHRs and associated criteria for comment (see Appendix A: Category of Functionality). Public comment was open from March 3 to 31, 2006.²¹¹ Categories of functionality include identification and maintenance of patient demographics, medication, and diagnosis. Also incorporated is the ability to capture external clinical documents and the ordering of medications and tests. There are also workflow directives such as task assignment, inter-provider communication, scheduling, and report generation.

CCHIT focused its first efforts on ambulatory EHR products for the office-based physician and provider where most Americans receive their care. Following ambulatory products, CCHIT will focus on inpatient and network criteria and inspection processes. For each domain, it publishes a handbook that provides guidance on product eligibility, testing outcomes, appeals and complaints and marketing guidelines

On July 18, 2006, CCHIT announced certification of 18 vendors and two provisional certifications. As part of its active outreach, CCHIT presents its certification message to physicians, physician groups, payers and purchasers to communicate the benefits of selecting a CCHIT Certified product.

As evidenced by CCHIT’s July 18 announcement, vendors will use CCHIT's certification as a trump card with physician adoption and implementation. At the industry level, certification may be the only message that gets to physicians. To date, CCHIT has certified 20 products, though it should be noted that CCHIT does not evaluate usability.

While the literature from IOM, HL7, Gartner and CCHIT offers different perspectives, they each have a defining role in the adoption of EMRs. IOM establishes core delivery-related functionalities, HL7 establishes the standards, Gartner recommends how EHRs should work together and CCHIT certifies vendors that meet policy and standards into a usable format.

4.2.6 EMR Functionality in Cost-Benefit and Survey Literature

In the cost-benefit literature, Wang has categorized three levels of EMR functionality, described in Exhibit 12. Wang’s basic level corresponds to a Gartner Level 1; his descriptions of intermediate and advanced levels share elements of Gartner Levels 2 and 3.²¹²

Exhibit 12. Wang’s Three Levels of EMR Functionality²¹³

Basic EMR	Intermediate EMR	Advanced EMR
Online chart with: <ul style="list-style-type: none"> • Clinical note documentation • Results viewing 	Basic plus: <ul style="list-style-type: none"> • Electronic prescribing • Adverse drug prevention capability • Alternative drug suggestion 	Intermediate plus: <ul style="list-style-type: none"> • Lab order entry with testing guidance • Radiology order entry with test guidance • Electronic charge capture

Whereas Wang and Gartner have proposed theoretical constructs, Gans’ survey describes what functionalities physicians have adopted and correlates them to practice size.

Exhibit 13. EHR Capabilities as a Function of Number of Physicians in a Practice (Gans)²¹⁴

EHR Feature/Capability	Percent adoption by practice size			
	≤ 5	6–10	11–20	21+
Patient demographics	99	99	99	100
Visit/encounter notes	98	96	99	98
Patient medications	96	97	98	98
Past medical history	95	95	99	95
Problem lists	94	93	94	96
Laboratory results	89	87	94	97
Radiology/imaging results	75	72	87	89
Tracking immunizations	80	72	64	75
Drug interaction warnings	79	75	81	84
Drug reference information	76	80	78	79
Drug formularies	62	64	67	68
Clinical guidelines and protocols	64	62	71	64

Capabilities such as clinical notes, history, medication lists, and problem lists appear to be most commonly adopted by all physician practices. Results reporting functions for labs and imaging are adopted at a higher rate in larger physician practices. Drug interaction warnings and drug reference information rank lower in terms of adoption and are somewhat unevenly related to physician practice size. Drug formularies ranked near the bottom, though this may change with the impact of the Medicare Modernization Act and the increased need to manage drug formularies. However, direct electronic connectivity to a pharmacy is not described or emphasized in this survey.

The physician survey conducted by the American Academy of Family Physicians (AAFP) presents similar results of physician adoption rates (see Exhibit 14), with clinical guidelines ranking near the bottom and clinical documentation, problem lists, and medication lists ranking nearer the top.²¹⁵ E-prescribing is ranked highly; however, e-prescribing is not clearly defined in this case. It may range from a computer-generated prescription that is handed to a patient, to a computer-generated order that is faxed to a pharmacy, to an electronic connection that delivers the order directly to the pharmacist’s computer. It is estimated that less than 2 percent of ambulatory systems have a direct connection to pharmacies.

Exhibit 14. Physician Adoption Rates of EMR Functions – AAFP, 2005 EHR Survey

Benefits	0%–17%	18%–34%	34%–68%	68%–85%
Clinical Decision Support	+			
Support Research	+			
Manage Protocols	+			
Manage External Documentation	+			
External Communication	+			
Health Maintenance		+		

Benefits	0%–17%	18%–34%	34%–68%	68%–85%
ADE and Allergy Information		+		
Summary Record		+		
Intra-Office Communication		+		
Problem Lists			+	
E-Prescribing			+	
Data Retrieval			+	
Clinical Documentation			+	
Medication Lists			+	
Quick Access to Clinical Data				+

Legend: + Positive correlation, with no stat. significance

Although the functions that define an EMR are not codified, there is a core group of functions that, in various permutations, are often associated with an EMR.^{216,217,218,219,220} These frequently include the capacity to: capture and display clinical notes, display laboratory results, display diagnostic imaging results or reports, order drugs or diagnostic tests, and generate reports. Within these categories of functions there are widely varying levels of sophistication. One important way in which sophistication varies is the extent to which decision support is used to aid the provider in a number of ways, but especially in ordering medication and diagnostic tests and providing relevant treatment guidelines. Furthermore, the level of decision support may require different system architecture (i.e., single platform) or controlled terminology to generate rules and alerts.

Different functionality has significant implications for system performance. For instance, Nebeker reported that despite being completely computerized and having a CPOE, a VA hospital experienced a significant number of adverse events because the system was lacking certain decision support capabilities.²²¹ Wang has correlated different levels of function with different ROIs.²²²

In addition to functionality, usability also has implications for performance and accrual of costs and benefits. Usability is not only relevant to physician acceptance of a system but to patient safety and quality of care. Physicians need to enter and retrieve information quickly to maximize efficiency and facilitate prompt, accurate treatments. However, Ash notes that some systems are not designed for the interrupted workflow, due to multi-tasking or unexpected calls or events that characterize physician work patterns.²²³

Rose conducted two qualitative workflow studies to understand how usability could be improved.²²⁴ He found that one of the greatest challenges was balancing the need for timely and relevant information with the limited amount of space on the screen. Screen design and contrast were not always used effectively, and users often ignored important items such as alerts. In addition, physicians often did not use the provided templates because they were not suitable for the patient being cared for at the time. Though these studies were small and only examined one EMR product, they suggest the importance of usability for clinical applications.

4.2.7 Interoperability

The quantifiable benefits of interoperability, especially from the perspective of the physician, remain speculative, and the literature offers little insight into the influence of interoperability on physician adoption patterns. However, interoperability represents a unique capability that deserves special comment. It refers to the capacity to share electronic information among different individuals who may be using different information technology tools, in this case different EMRs. It is unique in the discussion of functionality because it includes not just the functionality of a given product but the electronic capabilities of the broader community. Ease of interoperability is related to a variety of factors, including the level of standardization of terms, vocabularies, and messaging standards, as well as the technical characteristics of EMRs and the “middleware” that may connect them. True interoperability requires a collaborative social and cultural environment.

Spearheading the largest private-sector interoperability effort is the EHR Vendor Association (EHRVA.org), an organization demanding collective involvement from its members. Its interoperability roadmap (http://www.ehrva.org/docs/roadmap_v2.pdf) mobilizes healthcare organizations to deliver on the IOM, HL7, and CCHIT vision.

The CCHIT initiative has addressed interoperability as part of the EHR criteria.²²⁵ The categories included are: laboratory and imaging, medications, immunizations, clinical documentation, secondary uses of clinical data, and administrative and financial data. The proposed categories address not only individual primary care needs but also population health efforts with connections for public health disease reporting, immunization registries, and quality improvement reporting.

In support of HHS and AHIC goals for interoperability, the Health Information Technology Standards Panel (HITSP) serves “as a cooperative partnership between the public and private sectors for the purpose of achieving a widely accepted and useful set of standards specifically to enable and support widespread interoperability among healthcare software applications, as they will interact in a local, regional and national health information network for the United States.”²²⁶ Funded by HHS and ONC, the HITSP was convened by the American National Standards Institute (ANSI) and a number of partners, including HIMSS, the Advanced Technology Institute (ATI) and Booz Allen Hamilton. AHIC, known as the Community, was chartered by the Secretary of HHS in 2005 to provide input and recommendations to HHS on making health information and records digital and interoperable, with consideration for privacy and security. The Community is charged with achieving these goals in a “smooth, market-led way.”²²⁷

In projecting the future benefits of EMRs, the most robust benefits are reserved for the imagined state in which providers, hospitals, pharmacies, labs, and other key links in the health care chain are all interconnected with interoperable systems that can share health care information in an almost frictionless environment.^{228,229} Walker has estimated that in such a future state, the net economic benefit would be approximately \$377 billion over the first 10 years and \$77 billion a year after that.²³⁰ Others, such as Baker,²³¹ have taken a more restrained view in regard to net economic benefit.^{232,233,234} Irrespective of the size of benefits, the accrual of interoperability

benefits is relevant for EMR adoption. Benefits from interoperability can serve as motivators for physician adoption provided physicians reap such benefits.

Understanding the spectrum of EMR functionality and usability is important for a variety of reasons. First, it underscores the complexity of the decision that office physicians must face. As described earlier, this complexity presents time- and cost-related challenges in the selection process and is a barrier to adoption. Second, in developing an economic framework of physician adoption of EMR, we have proposed to describe the adoption of progressively more sophisticated functionalities rather than to model EMR adoption in a dichotomous yes/no fashion. This will require organizing functionality in categories of sophistication. Though a uniform approach does not exist, the literature provides some guidance in this regard.

4.3 EMRs, CPOE, and Health Care Quality Improvement

The Institute of Medicine (IOM) has articulated six aims of quality: safety, effectiveness, efficiency, patient-centeredness, timeliness, and equity.²³⁵ We will provide an overview of the literature that assesses the role played by HIT, especially EMRs and CPOE, in promoting the first three of these aims: safety, effectiveness, and efficiency.

The alarming prevalence of medical errors has been attributed largely to the failure of systems, particularly paper-based information systems, and HIT has been widely proposed as a means to reduce medical errors.^{236,237,238} Further, it is widely asserted that HIT can improve the quality of care.^{239,240,241}

In 1991, Brennan and Leape published the Harvard Medical Practice Study,²⁴² which examined approximately 30,000 records from 1984 in 51 New York hospitals. They found that approximately 3.7 percent of hospitalizations had adverse events, of which 14 percent were fatal and 58 percent were preventable. These data were extrapolated and later presented in the IOM's report, "To Err is Human," which estimated that medical errors result in 44,000 to 98,000 deaths per year.²⁴³ Since then, a number of studies have estimated the occurrence of adverse drug events in alternative patient-care settings and populations. An examination of the literature on incidence and prevalence of errors in the ambulatory care environment yields these key findings:^{244,}
^{245,246,247}

- ▶ ADEs in ambulatory care appear to be fairly common, for example with rates of 5.5 per 100 patients.²⁴⁸
- ▶ Approximately one quarter to one third of ADEs in an ambulatory care environment may be preventable using such tools as computerized prescribing.
- ▶ The preponderance of errors leading to adverse patient outcomes are related to prescribing, monitoring, and dispensing.

We first review the literature on the links between EMRs and patient safety, followed by an examination of the evidence related to effectiveness and efficiency. A review of the literature in

Chapter 4.3 is essential to understanding the cost-benefit literature discussed in Chapter 4.4. A number of the studies related to the role of EMRs in improving safety and quality form the basis for the cost-benefit estimates associated with EMR adoption. In addition, this literature provides evidence on the types of benefits accrued and that have been shown to affect EMR adoption. Physician surveys suggest that quality enhancement is an important motivator of physician adoption.^{249,250,251} Examination of this literature is therefore relevant to the development of the economic framework.

4.3.1 The Role of EMRs and CPOE in Patient Safety

In this section we review the evidence that links use of EMRs to improvements in patient safety. The studies discussed are primarily focused on the inpatient environment, so their relevance to the ambulatory environment often requires extrapolation. In addition, many of the studies were done at premier institutions that are thought leaders in informatics, which may limit the generalizability of the findings. Examples of these institutions include: Harvard-Partners System, the University of Indiana–Regenstrief System, and the Intermountain Health Care System.^{252,253,254,255,256}

Although experiences in the ambulatory setting may differ from the inpatient environment, exposure to this literature may influence physicians' expectations of EMR benefits even in small practice settings. This literature also sheds light on the relationship between levels of EMR functionality and its potential to reduce errors. This relationship is relevant to our economic framework, where choices of alternative functionality levels have been associated with alternative benefit streams.

Bates and colleagues evaluated the impact of CPOE in preventing medical errors in three medical units over 4 years.²⁵⁷ After measuring the baseline rate of errors, the units were studied for 7 to 10 weeks over each of the successive years. With each year the sophistication of the system was enhanced. Though early functionality and corresponding error reduction were more modest, by the end of the study period the error rate fell 86 percent, from 142/1,000 patient-days to 27/1,000 patient-days. The extent to which safety is improved appears to correlate with the functionality of the system.

Evans and colleagues from LDS Hospital in Salt Lake City developed a computerized decision support tool to assist clinicians in ordering and using anti-infective medications such as antibiotics.²⁵⁸ They studied the impact of this medication ordering tool, which presents epidemiologic information and prescribing recommendations and warnings, on the care of 545 patients in an adult ICU. They compared outcomes to the pre-intervention control group, and found that compared to the control group the tool effectively reduced excess drug dosages (87 versus 405), antibiotic susceptibility mismatches (12 versus 206) and drugs orders to which patients were allergic (35 versus 146). As a result, the number of adverse events declined from 28 to 4.

Mullett and colleagues modified the anti-infective decision support tool described by Evans and assessed it in a pediatric ICU.²⁵⁹ They described a 59 percent decline in pharmacist interventions for errors related to drug dosing. The study also reported that physicians thought the system

improved their anti-infective choices. In other studies related to pediatric admissions, CPOE systems showed potential to reduce errors and ADEs. Potts and colleagues conducted a pre/post-CPOE implementation study of 541 patients admitted to a pediatric ICU.²⁶⁰ They found that prescribing errors declined from 30 to 0.2 per 100 orders (99 percent reduction) and potential ADEs declined from 2.2 to 1.3 per 100 (41 percent reduction). Similarly, Fortescue and colleagues assessed pediatric inpatient medication errors at two academic institutions and estimated that: 60 percent of these errors could have been prevented by a basic CPOE; 76 percent could have been prevented by a more advanced CPOE with decision support; and 19 percent could have been prevented by an electronic medication administration record (e-MAR).²⁶¹

Despite accumulating evidence that CPOE can reduce errors in the inpatient environment, a growing number of recent studies show ambiguous or negative impact of CPOE with lower levels of functionality or usability. Gandhi analyzed error rates at two clinics that hand-wrote prescriptions and two that had basic computerized prescribing, and found no significant difference in errors between the two types of sites.²⁶² He speculated that more advanced capabilities, including dose and frequency checking, could have prevented 95 percent of the ADEs.

Using surveys, focus groups, and interviews at an academic medical center, Koppel (from the University of Pennsylvania) and colleagues identified 22 categories of error they attributed to a CPOE.²⁶³ They grouped these errors into two categories: 1) errors generated by fragmentation of data because of a failure to appropriately integrate information systems; and 2) human-interface flaws in which machine rules failed to correspond to work organization or behavior. Seventy-five percent of house staff reported observing a CPOE-related error at least weekly.

Nebeker and colleagues examined errors and ADEs in a Veterans Administration hospital with CPOE.²⁶⁴ They identified 483 significant adverse events, or 52 ADEs per 100 admissions. Of these, 9 percent resulted in serious harm. Despite the CPOE, medication errors contributed to 27 percent of these ADEs, with a majority being moderate errors (91 percent) caused by adverse drug reactions. The errors occurred at the following stages of the process: ordering (61 percent), monitoring (25 percent), administration (13 percent), and dispensing (1 percent). The authors observed that the CPOE system lacked decision support for drug selection, dosing, and monitoring, and correlated the errors and adverse events to this gap in functionality.

A study published by Han and colleagues from the University of Pittsburgh Department of Critical Care described an increase in mortality after implementing CPOE in a pediatric ICU.²⁶⁵ Retrospective analysis of mortality 13 months pre-implementation and 5 months post-implementation showed that mortality increased significantly from 2.8 percent to 6.57 percent. Some have argued that the commercial system implemented in this case was not appropriate for the ICU environment.²⁶⁶ In addition to inadequate functionality, poor usability, insufficient training, and inadequate re-engineering of work processes can also compromise performance so that maximum benefit is not achieved.

Interestingly, Upperman and colleagues, also from the University of Pittsburgh, previously reported that the same CPOE system when implemented in a non-ICU setting produced a reduction in transcription errors and harmful ADEs.²⁶⁷

An analysis by Sittig suggests that failure of the CPOE system to reduce ADEs or mortality is not attributable solely to the system's functionality.²⁶⁸ Examination of workflow, training of staff, and connectivity analysis are all necessary for successful CPOE implementation. Han has also suggested that failure to address such factors may contribute to an increased rate of errors or mortality.²⁶⁹ As noted above Upperman, found that the CPOE at the University of Pittsburgh reduced errors in hospital wards outside the ICU.²⁷⁰ This underscores the notion that usability may vary significantly with changes in the clinical environment.

4.3.2 The Role of EMRs in Improving Effectiveness

In this section we examine the evidence for HIT, and specifically EMR embedded reminders (e.g. decision support) and evidence-based guidelines, to improve effectiveness of care through physician use of evidence-based practice. Evidence-based medicine is an approach to improve both the effectiveness and the efficiency of care. This is accomplished by promoting care shown to be effective and by limiting wasteful care that is less effective or perhaps even harmful. The literature suggests that much of the health care provided today is not evidence-based.^{271,272}

Evidence from Safran, Christakis, Evans, and others suggests that, especially in the domain of medication administration, HIT can promote more appropriate and more cost-effective care.^{273,274,275} In the early 1990s, Safran evaluated the impact of embedding HIV treatment guidelines in a computerized patient record in an 18-month randomized controlled study.²⁷⁶ The physicians assigned to receive the guidelines (i.e., the intervention group) showed significantly higher rates of compliance with recommended guidelines than the control group, the physicians who did not receive the guidelines—85 percent versus 64 percent. However, no differences in ER visits, hospitalizations, or mortality were noted.

In a study focused on the provision of electronic guidance to pediatric providers, Margolis showed increased compliance with protocols for otitis media and pharyngitis.²⁷⁷ However the physicians found the required documentation to be onerous and refused to use the system after 5 weeks. In a randomized study, Christakis and colleagues provided one group of pediatric providers with real-time electronic advice regarding a shortened course of antibiotic therapy for otitis media, resulting in a 34 percent increase in prescribing the recommended therapy when compared with the providers without the electronic advice.²⁷⁸

The VA is an institutional early adopter of EHRs, and its system supports clinical reminders and suggestions for a broad range of clinical services, including screening and prevention. For a number of these interventions, the VA has significantly higher rates of compliance with recommended guidelines when compared to Medicare populations.²⁷⁹ Asch and colleagues evaluated VA quality of care by comparing 12 Veterans Health Administration (VHA) health systems with care in 12 communities using a comprehensive quality of care measure.²⁸⁰ The VA scored higher for overall quality, chronic disease care, and preventive care, but not for acute care. As noted by Asch, the VA, which has a robust EHR that provides a broad spectrum of

clinical reminders, consistently demonstrates high levels of compliance with clinical guidelines relevant to prevention and screening.

A series of articles from Regenstrief describe a more negative experience with providing electronically mediated guidelines to improve care. Tierney and colleagues provided primary-care physicians and pharmacists with electronic evidence-based cardiac care suggestions over a period of 1 year and 3,419 primary-care visits.²⁸¹ The investigators reported their findings in 2003 and found no impact on quality of life, medication compliance, utilization, or costs. Other studies that have examined evidence-based treatment suggestions for asthma, hypertension, diabetes, and coronary heart disease found no improvement, or marginally improved compliance, among physicians.^{282,283,284}

In a series of articles, Schriger and colleagues from UCLA described the effectiveness of evidence-based guidelines embedded in an EHR identified as an Emergency Department Expert Charting System.^{285,286} They examined the effectiveness for three clinical scenarios: exposure of health care workers to body fluids; the care of back pain; and the care of infants with fever. The investigators found that although documentation improved in all three scenarios, it only improved the appropriateness of testing and treatment in the care of exposed health care workers. It had the least impact on the care of febrile infants.

4.3.3 Role of EMRs on Efficiency and Cost

Efficiency is another dimension of quality described by the IOM.²⁸⁷ This may be achieved by limiting unnecessary care or providing appropriate care in a more cost-effective manner. Enhanced efficiency may be achieved through a variety of mechanisms, including error reduction, provision of more cost-effective medications, and care based on existing evidence. Other potential mechanisms include reduction of redundant tests and more effective use of providers' time. We will briefly touch on each of these below. The discussion on efficiency is relevant for two reasons. These studies form the basis of the benefits estimates discussed in Chapter 4.4. In addition, this literature points to the magnitude of benefits that can potentially accrue to a physician, which is highly relevant for EMR adoption.

4.3.3.1 Potential Cost Savings and Associated Error and Adverse Event Prevention

Error prevention has implications not only for patient safety, but for cost efficiency. Errors that result in adverse events may lead to further care. In the outpatient environment, an adverse event may lead to an office or ER visit and may ultimately result in an expensive hospitalization. Inpatient errors may prolong a hospital stay and require additional expensive interventions.

Classen and colleagues affiliated with Intermountain Health System in Utah conducted a case-controlled study to estimate excess costs, length of stay, and mortality associated with inpatient medical errors.²⁸⁸ There were 1,580 ADE cases and 20,197 controls. The authors found an ADE rate of 2.43 per 100 admissions with mortality rates of 3.5 percent and 1.05 percent for the cases and controls respectively. Hospital length of stay was a mean of 7.69 days for cases and only 4.46 days for the controls. The excess cost due to an ADE was \$2,262. In a retrospective cohort study, Field and colleagues analyzed the costs associated with an ADE in 1,200 older adults who

had experienced an adverse event in the ambulatory setting.²⁸⁹ The investigators used a matched, randomly selected control group. After controlling for a variety of factors including comorbidity, the number of medications, and recent hospitalizations, the authors found that adverse events were associated with \$1,300 of additional cost. When the analysis was confined to preventable adverse events, the additional cost was \$1,900. This is comparable to the \$2,262 in excess costs associated with inpatient errors identified by Classen above. Jha and colleagues reviewed hospital admissions to determine which may have been related to outpatient ADEs.²⁹⁰ Of 3,238 admissions, the authors judged that 76 were related to an ADE (1.4 percent). They calculated the cost of the 76 admissions to be \$1.2 million, or about \$15,800 per admission.

4.3.3.2 Redundant or Unnecessary Lab Tests

Redundant and unnecessary testing is a source of inefficiency and unnecessary patient burden. In a study published in 1998, Bates and colleagues estimated that 8.6 percent of routine hospital laboratory tests appeared redundant.²⁹¹ In a second study published in 1999, Bates and colleagues provided physicians with an electronic reminder, when appropriate, that a test appeared redundant.²⁹² The authors reported that 69 percent of tests were canceled in response to these reminders. Of the 31 percent that were not canceled, 41 percent appeared to be appropriate over-rides.

Tierney and colleagues published the results of three prospective randomized controlled studies in 1987, 1988, and 1990, in which the investigators explored whether physician testing behavior could be favorably influenced by providing different kinds of electronic information at the time of ordering. In the first study, he and colleagues from Regenstrief provided physicians with information regarding the number of previous tests and their results.²⁹³ They found that after showing physicians previous tests conducted, the volume of new tests decreased by 16.8 percent and test-associated charges decreased by 13 percent. In the second study, the “intervention” physician group was provided with the pre-test probability of a positive test.²⁹⁴ In the third study, the intervention group was provided with test cost data.²⁹⁵ Charges for tests declined 9 percent based on the second study and 13 percent based on the third study, with comparable declines in test volumes.

4.3.3.3 Cost-Efficient Prescribing and Generic Switching

Using appropriate generic drugs or substitution with a more cost-effective alternative may be a significant source of savings. As described earlier, Evans analyzed the impact of an anti-infective management system.²⁹⁶ He examined the impact on the cost of anti-infective medications by comparing medication costs for patients who always received the recommended treatment (Group 1) to costs for patients who did not always receive the recommended treatment (Group 2). He also compared these to medication costs per patient prior to system implementation (Group 3). Medication costs for Groups 1, 2, and 3 were \$102, \$427, and \$340, respectively. Length of stay and hospital costs for these groups followed a similar pattern and were 10 days and \$26,000, 17 days and \$45,000, and 13 days and \$35,000, respectively.

Teich and colleagues found that a CPOE system that effectively prompted physicians to use a more cost-effective histamine blocker increased the frequency of drug orders from 15.6 percent

to 81 percent of histamine blocker orders.²⁹⁷ Mullett used network health plan data to assess the impact of an e-prescribing system with decision support that provided clinicians with messages guiding them toward lower cost therapies.²⁹⁸ When compared to a control group, the study found that the average savings was \$465 per member per month (PMPM) for new prescriptions and \$873 PMPM when all pharmacy claims were considered. A recent study sponsored by Express Scripts suggested that total annual savings in the 48 contiguous states could reach \$20 billion if generic substitution were standard practice.²⁹⁹

4.3.3.4 Efficiencies Related to Provider Time Utilization

The literature regarding EMRs and provider efficiency is largely focused on the inpatient environment. The conclusions vary significantly and are often different for physicians and nurses. Poissant and colleagues recently performed a literature review of the impact of EHRs on the efficiency of physicians.³⁰⁰ The authors identified 23 papers that were sufficiently rigorous to meet their inclusion criteria. They found that in hospitals, the use of bedside terminals or central station desktops reduced nurse documentation time by about 25 percent. However, bedside CPOE terminals increased physician documentation time by about 18 percent. Physician use of central station desktops for CPOE was significantly more inefficient, increasing documentation time 98 to 328 percent. It is not clear whether these inefficiencies were offset by other efficiency gains related to easy access to data.

There is less written about the ambulatory environment, though multiple authors note that efficiency and productivity often decline in the immediate post-implementation period and may persist for months.^{301,302,303} Formal time-motion studies are limited and are also inconsistent in their findings. For example, Overhage and colleagues found that an outpatient EMR initially increased encounter time per patient by 2.12 minutes (from 9.8 to 12).³⁰⁴ In another study, it was shown that the time spent on patient order entry increased from 2.1 percent to 9 percent of the workday after the implementation of an inpatient CPOE.³⁰⁵ A time-motion study by Pizziferri and colleagues measured physician perceptions against actual workflow changes.³⁰⁶ The study suggested that the average time for clinical documentation was reduced by 0.5 minute with EMR usage; however, only 29 percent of those completing the survey felt that the EMR could improve the documentation times. There are also a number of anecdotes and case studies that suggest that EMRs can promote provider efficiency in the ambulatory environment.^{307,308,309,310,311,312,313,314,315,316}

4.4 Return on Investment of EMR Adoption

ROI is central to economic models of technology diffusion. Physicians cite excessive cost in relation to expected benefits as an obstacle to EMR adoption. Net benefits (benefits minus costs) vary by system functionality as well as mode, sequence, and pace of implementation and with the timeline of measurement of the net benefits. In Wang's projection model, he reports a strongly positive net benefit 5 years post-implementation, but if measured 2 years post-implementation there is an anticipated net loss.³¹⁷

We identified nine ROI studies of note in the peer-reviewed literature; these are listed in Exhibit 15. Only four focus exclusively on the ambulatory environment. Hillestad and colleagues include

costs and benefits of an ambulatory EMR as part of their national estimates of widespread EMR adoption.³¹⁸ Khoury’s study is less relevant because it refers to older technology in the setting of a very large practice, which is not the focus of our study.³¹⁹ Wang projects EMR costs and benefits based on a predictive model,³²⁰ and only the Miller study is based on empirical measurement, albeit retrospective.³²¹

Exhibit 15. EMR Cost-Benefit Studies

Interoperability ROI	Inpatient/IDN ROI	Ambulatory ROI
Walker, et al./CITL, 2005; projected large ROI by creating a national interoperable network of EMRs ³²²	Birkmeyer, et al., 2002; showed positive ROI for CPOE implemented in 200-bed and 1,000-bed hospital ³²³ Kian, et al., 1995; projected positive ROI at MD Anderson Cancer Center ³²⁴ Schmitt & Wofford, 2002; projected strong ROI at Virginia Mason Medical Center ³²⁵	Wang, 2003; model predicted strong ROI for advanced ambulatory EMRs ³²⁶ Johnston, et al./CITL, 2003; model predicted strong ROI for advanced ambulatory CPOE ³²⁷ Miller, et al., 2005; retrospective assessment of 14 physician practices showed positive ROI ³²⁸ Khoury, 1998; showed positive ROI of older system for large Kaiser practice ³²⁹
Hillestad, et al., 2005; projected positive net benefit of EMR adoption in inpatient and ambulatory settings ³³⁰		

A number of these studies rely on expert opinion and previously published literature on the quality and efficiency benefits associated with EMR adoption. For instance, Birkmeyer and colleagues relied heavily on expert opinion to estimate costs associated with hypothetical CPOE implementations at a 200-bed and a 1,000-bed hospital.³³¹ Wang³³² and Johnston³³³ used literature sources and expert opinion to estimate costs and benefits of EMRs and CPOE, respectively, in hypothetical ambulatory care practices. Kian and colleagues³³⁴ and Schmitt³³⁵ used similar approaches to estimate the ROI for large HIT systems in two large integrated delivery networks.

Another issue is that a relatively small group of authors have dominated this literature.^{336,337,338,339,340,341,342,343,344} Although this group represents an outstanding cohort of well-regarded investigators, many of these authors are writing about system costs and benefits at a handful of premier academic institutions and technologically sophisticated organizations. Results obtained in these highly sophisticated environments may not be generalizable to the broader community.

Despite these limitations, it is important to understand the costs, benefits, and ROI on EMR adoption, because, as discussed in Chapter 4.5, these are important considerations for physician adoption and are therefore relevant to the framework.

4.4.1 EMR Costs

EMR adoption is influenced by a variety of factors, including hardware costs, software costs, the costs of implementation and training, and costs associated with reduced productivity that occur in the early stages of implementation. These costs are generally captured in the literature, though

the manner in which they are classified varies. Exhibit 16 provides an overview of the costs cited in the cost-benefit literature.

Exhibit 16. Cost Breakdown—Cost-Benefit and Survey Literature

	Wang, 2003 ³⁴⁵	Miller, 2005 ³⁴⁶	AAFP Vendor Survey ³⁴⁷	Gans, 2005 ³⁴⁸
Costs ¹	Present Value of Financial Costs per Physician (6-Yr Cum) ⁴	Financial Costs per FTE Provider (1-Yr)	Financial Cost over 3-Year Period (EHR Stand-Alone System, Average Total Cost for Three-Physician Practice)	Financial Costs per Physician Estimated by Survey (no timeframe noted)
Acquisition Costs²	\$42,900	\$43,405	\$49,837⁵	\$33,000
• Hardware	\$12,301	\$12,749	\$20,590	
• Software	\$8,527		\$15,794	
• Software training and installation		\$22,038	\$3,020	
• Workflow redesign, training, and paper-electronic chart conversion	\$3,400			
• Productivity loss during implementation	\$10,667	\$7,473		
• Other implementation costs		\$1,145	\$1,998	
• Technical/network system support	\$7,994		\$3,151	
Annual Costs³		\$8,412	\$2,642	\$18,000 (\$1,500/mo.)
• Software maintenance and support		\$2,439		
• Hardware replacement		\$3,187		
• Internal IS/external IS contractors		\$2,047		
• Other ongoing costs		\$739		

1. Range of cost and benefit estimates depends on practice size and level of EMR technology used.
2. Acquisition costs are out-of-pocket costs incurred at the outset of purchasing an ACPOE or EMR system, including licenses or subscription fees, interface development, knowledge base development and customization, implementation or integration costs, and training fees.
3. Annual costs are the costs incurred to support a system, including ongoing license or ASP subscription fees, maintenance, and infrastructure costs.
4. Present value of annual costs, assuming a 5% discount rate.
5. Please note: the total acquisition cost reported by the authors does not equal the sum of individual cost components in this table

Despite the challenges in making cost comparisons across different studies, the costs per physician provider range between \$33,000 and \$50,000. The average costs per physician, cited by Davies Award winners who provided these data, are approximately \$39,000, which falls within the range described in Exhibit 16. Although the Hillestad model does not provide per-physician costs, they estimate national adoption costs at \$17.2 billion, which includes one-time purchase and maintenance costs.³⁴⁹

There is a great deal of cost variability at the practice level. Some of this variability is due to the negotiating ability of the physician purchasers. Those with strong negotiating skills are able to extract a significantly lower price from vendors.³⁵⁰ There is also evidence that cost varies by size of practice. Gans notes that costs per physician tend to be higher in smaller practices and lower

in larger practices,³⁵¹ and in Johnston’s model of CPOE adoption, described in Exhibit 17, cost varied significantly with practice size (and level of functionality).³⁵² This is attributed to economies of scale in which certain fixed costs are spread over a larger number of physicians.^{353,354} As price varies significantly with negotiations, larger practices may have increased negotiating power over small practices.³⁵⁵

Cost varies with functionality, although detailed analyses of this variation are not available in the literature. In prior interviews with vendors, we found them generally unwilling to unbundle products and assign costs to specific levels of function.³⁵⁶ Reluctance to offer cost data relates to the pricing variability in an environment where negotiation skills play a significant role in determining the product’s end cost.³⁵⁷

Gans’ survey suggests that most physicians have adopted relatively basic systems.³⁵⁸ Exhibit 17 describes how CPOE system costs vary by both practice size and functionality in Johnston’s model.³⁵⁹

Exhibit 17. CPOE System Cost Variations³⁶⁰

	Basic Prescription Orders	Basic Prescription and Diagnostic Orders	Intermediate Prescription Orders	Intermediate Prescription and Diagnostic Orders	Advanced Prescription and Diagnostic Orders
1 Provider					
Total 5-year costs	\$12,400	\$19,570	\$30,200	\$58,670	\$505,400
5 Providers					
Total 5-year costs	\$12,400	\$19,440	\$18,530	\$35,640	\$122,000
10 Providers					
Total 5-year costs	\$12,400	\$19,420	\$17,070	\$32,760	\$74,020
25 Providers					
Total 5-year costs	\$12,400	\$19,410	\$16,190	\$31,040	\$45,260
50 Providers					
Total 5-year costs	\$12,400	\$19,410	\$15,900	\$30,480	\$35,680

Adapted from Johnston, et al., 2003

The time associated with the selection process has been cited as a significant barrier to adoption.³⁶¹ The cost-benefit literature does not explicitly account for the time and costs associated with the selection process. For self-employed physicians, this time can be represented as an income loss because it represents hours that could have been devoted to patient care and revenue generation.

Training costs are often underestimated, particularly in the earlier literature,³⁶² and Gans³⁶³ notes that implementation costs tended to be almost 25 percent higher than originally expected. This adds uncertainty to the realization of net benefits, and uncertainty of benefits is another impediment to adoption.³⁶⁴

4.4.2 Financial Benefits

Exhibit 18 summarizes the categories of benefits described by the EMR cost-benefit studies relevant to the ambulatory environment.

Exhibit 18. Benefit Breakdown—Cost-Benefit Literature

		Wang, et al., 2003 ³⁶⁵	Miller, et al., 2005 ³⁶⁶
Benefit Category	Benefit	Present Value of Financial Benefits per Physician for EMRs (6-year cumulative)	Financial Benefits per FTE Provider for EMRs per Year (estimated after year 1)
Clinical Utilization	Drug savings	\$55,384	
	Reduced radiology use	\$13,332	
	Reduced laboratory use	\$3,855	
Patient Safety	Reduction in ADEs	\$7,430	
Workflow Efficiency	Chart pull savings	\$12,988	
	Transcription savings	\$11,690	\$5,334
	Personnel savings (excl. transcription savings)		\$6,759
	Paper supply savings		\$1,051
Revenue Cycle	Reduction in billing errors	\$12,207	
	Improved charge capture	\$12,368	
	Increased revenue from increase visits		\$2,664
	Increased coding levels		\$16,929

In the Wang³⁶⁷ and Johnston³⁶⁸ models, reductions in ADE and redundant laboratory tests in addition to more cost-effective drug utilization played a prominent role in driving net benefits. However, Miller did not cite these as benefits in his study of 14 physician offices.³⁶⁹ Wang notes that these benefits will only accrue to physicians whose revenue stream comes from capitated payments. In such environments, physicians are responsible for the total cost of care they render and reductions in that cost, whether from reduced lab tests or medical errors. Wang estimated that physicians working in highly capitated environments using EMRs with the most robust functionality would realize a net savings of \$86,400 per physician over 6 years.

The positive association with a capitated reimbursement environment is consistent with Gans' finding that HMO-owned practices are more likely to adopt EMRs than physician-owned practices.³⁷⁰ In Wang's predictive model, physicians who worked exclusively in fee-for-service environments experienced a net financial loss after EMR implementation.³⁷¹ Hillestad uses a projection model similar to Wang and estimates the national benefits from implementation of an ambulatory EMR to average \$10.6 billion.³⁷² Sources of savings include transcription, chart pulls, lab and radiology ordering, and drug usage. Avoidance of ADEs in the ambulatory care setting is estimated to result in \$3.5 billion savings per year on average.

In contrast, Miller³⁷³ noted a substantial net financial benefit without invoking benefits that might accrue from decreased ADEs, redundant tests, or more cost-effective prescribing practices.

In the practices studied by Miller, increased revenue realized from more effective documentation and coding, combined with decreased costs from reduced transcription and other types of labor, were sufficient to more than offset the cost of implementation. The average net benefit in these 14 practices was approximately \$33,000 per FTE provider per year. Miller’s estimates were based on retrospective measurements of actual implementations, whereas Wang’s estimates were based on a predictive model.

Using a variety of different measures and metrics, some Davies Award winners also quantified benefits realized post-implementation; these are summarized in Exhibit 19. More-granular categories of benefit are described in this table than are described by Wang or Miller, and these more detailed descriptions may be useful as we build an explanatory economic framework. In general, the types of benefits tend to resemble those cited by Miller more than those cited by Wang, because ADEs, reduction in redundant tests, and more cost-effective drug utilization are not mentioned as benefits by the Davies winners.

Exhibit 19. Davies Award Winner Documented Benefits

Category	Benefit	RiverPoint Pediatrics ³⁷⁴	Pediatrics at the Basin ³⁷⁵	Sports Med & Orthopedic Specialists ³⁷⁶	North Fulton Family Medicine ³⁷⁷	Southeast Texas Medical Associates ³⁷⁸
Quality	Increased immunization rate	50% to 95%				
	Decreased patient wait time	1+ hr/visit to 36 min/visit				
	Decreased drug refill time	24–48 hr to 15 min				
	Decreased telephone turnaround time	24+ hr to 15 min or less				
Revenue Cycle	Reduced claim denials	30% denials to 0% denials				\$102,000
	Increase in overall collections					\$1,400,000
	Increased billable charges	\$56 avg. /encounter to \$78 avg. /encounter				\$150,000
	Increased collection rate	52% to 88%				
	Decreased insurance turnaround time	30–60 days to 15 days				
Supply Cost	Reduced supplies costs					\$380,000
	Reduced chart costs			\$10,000/yr		\$22,000
Workforce Efficiency	Reduced time costs for handling phone calls					\$103,000
	Reduced chart staff					\$120,000

Category	Benefit	RiverPoint Pediatrics ³⁷⁴	Pediatrics at the Basin ³⁷⁵	Sports Med & Orthopedic Specialists ³⁷⁶	North Fulton Family Medicine ³⁷⁷	Southeast Texas Medical Associates ³⁷⁸
	Reduced chart handling (searching, pulling, storing, and managing)	20–30 pulls/day to 0 pulls/day	\$16,800 in reduced charting and chart pulls		625 min/day to 0 min/day chart handling, 330 min/day to 0 min/day searching for chart	
	Decreased charting time	30–60 min/visit to 10–15 min/visit				
	Lab result handling				570 min/day to 0 min/day	
	Referral letters				180 min/day to 0 min/day	
	FTE (office support)		\$20,000–\$30,000/yr	\$25,000/yr		
	Transcription costs	\$500/month to \$0/month	\$10,000/yr	\$43,200/yr		\$340,000
	Transcription processing				705 min/day to 0 min/day	
	Increased patient volume	2,200 pt to 4,225 pt	\$1,000–\$1,400/yr			
Capacity Utilization	Increased number of patient visits/day	15–20 pt/day to 28+ pt/day				
	Eliminated chart storage room	1 room to 0 rooms	\$5,000/yr			

As noted earlier, levels of cost and benefit, and hence net benefit, are likely to vary by functionality, usability, and integration. More basic systems are generally less costly; however, they may yield less benefit. Both Wang³⁷⁹ and Johnston³⁸⁰ suggest that more robust functionality yields more significant benefit in a manner that is disproportionate to the increase in cost, so that net benefit is significantly increased. In Wang’s and Johnston’s models, a substantial source of benefit was attributable to reductions of ADE and increased generic switching, and functionality that included robust e-prescribing and decision support software was essential to realizing that benefit. And in both models, more basic systems resulted in a net loss.

Exhibit 20. EMR Net Return per Provider by Level of Function – Wang³⁸¹

Basic EMR	Intermediate EMR	Advanced EMR
Online chart with: <ul style="list-style-type: none"> Clinical note documentation Results viewing 	Basic plus: <ul style="list-style-type: none"> Electronic prescribing Adverse drug prevention capability Alternative drug suggestion 	Intermediate plus: <ul style="list-style-type: none"> Lab order entry with testing guidance Radiology order entry with test guidance Electronic charge capture
(\$18,200) Net Cost	\$44,600 Net Benefit	\$86,400 Net Benefit

Exhibit 21. CPOE Net Return per Provider (Johnston)³⁸²

	Basic Prescription Orders	Basic Prescription and Diagnostic Orders	Intermediate Prescription Orders	Intermediate Prescription and Diagnostic Orders	Advanced Prescription and Diagnostic Orders
1 Provider					
Year 5	(\$1,436)	(\$6,912)	\$31,350	\$24,450	(\$365,700)
5 Providers					
Year 5	(\$1,436)	(\$6,784)	\$43,020	\$47,470	\$17,870
10 Providers					
Year 5	(\$1,436)	(\$6,768)	\$44,480	\$50,350	\$65,820
25 Providers					
Year 5	(\$1,436)	(\$6,759)	\$45,360	\$52,080	\$94,590
50 Providers					
Year 5	(\$1,436)	(\$6,756)	\$45,650	\$52,660	\$104,200

Adapted from Johnston, et al., 2003

However, it is not clear that the increased net benefit associated by Wang and Johnston with advanced functionality is well substantiated or widely generalizable. Practices such as those cited by Miller³⁸³ and the Davies Award winners reported no financial benefits related to reduction in ADE or better drug utilization. In these practices, the added cost associated with robust e-prescribing and decision support may not yield the disproportionately larger net benefit predicted by Wang and Johnston. Thus, although cost may be averted by this added functionality, the savings may accrue largely to payors because of fee-for-service reimbursement.

4.5 Practice and Physician Characteristics that Influence EMR Adoption

There is a well-documented evidence on various physician and practice characteristics that correlate with EMR adoption.^{384,385,386,387,388} We reviewed a broad range of surveys and identified a small number of recent methodologically sound articles that were highly relevant to physician office EMR adoption and implementation. These are:

- 1) *“Information Technologies: When Will They Make It into Physicians’ Black Bags?”* by Audet, et al., 2003³⁸⁹

Audet conducted a 3-month mail survey of U.S. physicians involved in direct patient care to investigate their current use of, future plans for, and perceived barriers to the adoption of HIT (including electronic medical records [EMR], CPOE, clinical decision support systems [CDSS], and e-mail). The survey was sent to a random sample of 3,598 U.S. physicians from an AMA list of members and nonmembers. The response rate was 52.8 percent. Specialists likely to be involved in care only for short periods (e.g., radiologists, dermatologists) were excluded. Audet examined variables such as physician demographics, practice size, mode of compensation, use of various IT tools, and barriers to adoption.

- 2) “*Which Physicians and Practices Are Using Electronic Medical Records?*” by Burt and Sisk, 2005³⁹⁰

Burt and Sisk analyzed 3 years of data (2001, 2002, and 2003) from the National Ambulatory Medical Care Survey (NAMCS), which included more than 3,000 office-based patient care physicians (response rate 56 percent). The NAMCS is an annual survey conducted by the National Center for Health Statistics (NCHS) that uses a probability sample of physicians categorized as being predominantly associated with office-based patient care. This study examined the relationship between the use of EMR technology and physician and practice characteristics.

- 3) “*Medical Groups’ Adoption of Electronic Health Records and Information Systems,*” by Gans, et al., 2005³⁹¹

Gans conducted a national survey of medical group practices of three or more physicians and conducted a series of interviews and practice site visits to assess physician adoption of HIT and EHRs. The sample of group practices was drawn from the Medical Group Management Association’s national database of 34,490 medical groups that was assembled by the authors for a previous project. It included practices of three or more physicians. The authors conducted the survey during January and February 2005 (response rate 21.1 percent). In addition to examining the physician adoption rate of EHRs, the authors asked the physicians to: 1) identify which EHR functionalities they used; 2) rate the benefits of the EHR to their practice; 3) rate the barriers to EHR adoption, particularly with regard to implementation; and 4) indicate which government or private-sector actions could ease their decision-making process in adopting EHRs.

In addition to these studies, other useful surveys include those conducted by the American Academy of Family Physicians and the Center for Health Information Technology³⁹² and the Medical Records Institute.³⁹³ Another heavily cited source is the AMA Physician Marketplace Report.³⁹⁴

Because practice size figures prominently in a number of studies, we first review the data that describe the distribution of practices by size. We then examine the role of the following practice attributes in promoting EMR adoption: practice size, ownership structure, mode of compensation, specialty, and location; and finally the role of the physician attributes of gender, age, and specialty.

4.5.1 Practice Characteristics

4.5.1.1 Distribution of Physicians and Physician Practice Size Among Practicing Physicians

After excluding federally employed physicians and physicians currently in residency training programs, the AMA Physician Marketplace Report divides physicians who provide patient care into three large practice categories and provides estimates for the number of physicians in each category: 1) self-employed physicians (366,403; 65.5 percent); 2) physicians who are employees of physician-owned groups (46,877; 8.4 percent); and 3) physicians who are employed by non-

federal institutions such as hospitals, medical schools, state governments, and HMOs (146,113; 26.1 percent).³⁹⁵ Within the third group, there are approximately 10,000 physicians who work in HMOs.

The AMA report sorts self-employed physicians by practice size (see Exhibit 22). Approximately 135,569 (37 percent) are solo practitioners. Approximately 95,265 (26 percent) work in practices of two to four physicians, and 54,960 (15 percent) work in practices of five to nine physicians. Approximately 17 percent work in practices of 10 to 49 physicians, and only about 5.5 percent work in practices of more than 50 physicians, according to this report.

Exhibit 22. AMA Physician Marketplace Report: Patient Care Physician Practice Categories³⁹⁶

Self-Employed Physicians		Physician-Owned Practices: Employee Physicians		Non-Federal Institutions: Employee Physicians	
Total 366,403 (65.5%)		Total 46,877 (8.4%)		Total 146,113 (26.1%)	
No. of Physicians	Percent	No. of Physicians	Percent	Institution Type	Percent
1	37.3	1	0.8	Hospital	29.4
2-4	25.8	2-4	31.6	Med School/ University	28.4
5-9	15.1	5-9	25.7	State/Local Government	9.2
10-49	16.5	10-49	20.9	HMO	6.9
50-100	2.5	50-100	7.4	Ambulatory Sites	2.5
100+	2.9	100+	13.5	Other	23.7

Adapted from Kane, 2004.

According to the AMA report, smaller physician practices (one to nine physicians) include 286,345 physicians and account for 78 percent of all self-employed physicians. If physicians employed by physician-owned groups are included in addition to self-employed physicians, approximately 313,595 physicians or 76 percent of self-employed and contracted physicians work in practices of one to nine physicians.

Based on their sample, Burt and Sisk estimated that approximately 88 percent of physicians practice in groups of nine or less,³⁹⁷ and Casalino and colleagues estimated that approximately 82 percent of physicians practice in groups of nine or less.³⁹⁸ Though there is likely some variability related to sampling methodology and timing, it is reasonable to state that, after excluding government employees, approximately 75 to 80 percent of physicians work in practices of one to nine physicians.

4.5.1.2 Practice Size and Proclivity to Adopt EMRs

Three relatively recent large surveys have estimated the rate of EMR adoption by physicians and suggest that between 15 percent and 18 percent of physician practices have adopted an EMR (see Exhibit 23).^{399,400} Burt and Sisk found that when compared to solo practices, practices with 10 to 19 physicians were more than twice as likely to use EMRs.⁴⁰¹

Exhibit 23. Adoption of EMR and Practice Size

Burt and Sisk ⁴⁰²		Audet, et al. ⁴⁰³		Gans, et al. ⁴⁰⁴	
No. of Physicians	Percent	No. of Physicians	Percent	No. of Physicians	Percent
1	13.0	1	13.0	1–5	10.4
2–4	16.2	2–9	23.0	6–10	13.6
5–9	19.9	10–49	35.0	11–20	13.9
10–19	28.7	50+	57.0	21+	11.0
20+	38.9				

The survey literature has identified factors that may explain the correlation between size and adoption. Gans,⁴⁰⁵ Casalino,⁴⁰⁶ Wang,⁴⁰⁷ and others have observed that EMR implementation cost per physician may be lower in larger practices as there are economies of scale that are achievable in larger implementations. Implementation costs and financial barriers appear to be more significant for smaller practices.⁴⁰⁸ The Medical Records Institute survey suggests that access to capital and credit may be more of an issue for smaller practices.⁴⁰⁹ Gans suggests that lack of capital and productivity loss are of particular concern to small practices, which may have higher EMR-related costs per FTE than larger practices.⁴¹⁰ There are also time costs associated with selecting an EMR. Gans' survey suggests that smaller practices view vendor selection as a significant burden.

4.5.1.3 Practice Ownership and Means of Compensation

Practice ownership has been examined by Burt and Sisk, who divided ownership into three categories: HMO, physician ownership, and "other," which corresponds to hospital or delivery network-owned practices.⁴¹¹ Adoption was highly correlated with the ownership of the practice, with physician-owned practices least likely to adopt and HMO-owned practices most likely to adopt. Those in the "other" category were intermediate in their adoption proclivities. Practices owned by physicians or physician partnerships were two to three times less likely to adopt an EMR than practices owned by HMOs. In their analysis, practice ownership was the strongest predictor of adoption, with even higher correlations than practice size. Regardless of practice size, physician-owned practice adoption rates were only 15.6 percent, only modestly higher than adoption rates for solo practitioners and practices of two to four physicians. In this study, the forces driving adoption in larger practices are largely (but not completely) accounted for by the correlation between practice size and ownership; larger practices are more likely to have institutional ownership.

Others have found correlations between EMR adoption and means of compensation when this is defined as salaried versus nonsalaried compensation. Audet reported that 35 percent of salaried physicians use EMRs, compared with only 21 percent of nonsalaried physicians.⁴¹² A summary of these results is provided in Exhibit 24.

Exhibit 24. EMR Adoption by Type of Compensation and Percentage Ownership

Type of Compensation (Audet, et al.) ⁴¹³		Practice Ownership (Burt and Sisk) ⁴¹⁴	
Salary Status	Percent	Ownership	Percent
Salaried	35.0	Physician or physician group	15.6
Non-salaried	21.0	Hospital/IDN/Other	27.2
		HMO	52.7

4.5.1.4 Specialty

Specialty may refer to a practice characteristic or a physician characteristic. In this section we discuss the relationship between practice type (specialty versus primary care) and EMR adoption.

Audet, basing her findings on the 2003 Commonwealth Fund Survey, found that multi-specialty practices were more likely than primary-care practices to adopt EMRs.⁴¹⁵ In contrast, Burt and Sisk did not find different rates of EMR adoption between specialist and primary-care practices when broadly defined.⁴¹⁶ They note that the Commonwealth Fund Survey excluded certain specialties that do not provide longitudinal care, such as radiology, pathology, anesthesiology, and dermatology, and speculate that this exclusion may have resulted in the disparate findings in the two studies. Their study did, however, find correlation between individual physician specialty and adoption. These studies are summarized in Exhibit 25. We discuss these findings in Chapter 4.5.2.2.

Exhibit 25. Adoption of EMR by Specialty

Audet, et al. ⁴¹⁷		Burt and Sisk ⁴¹⁸	
Practice Type	Percent	Specialty	Percent
Primary care	23.0	Primary care	17.0
Specialists	28.0	Surgical	19.1
		Medical	17.0

Differences in adoption may also be explained by the availability of the “right” type of technology. Different specialties may have different EMR technology needs, and many commercial products have yet to address some of these specialized needs.^{419,420} In a study comparing pediatric residents to internal medicine residents, pediatric residents were more comfortable with template-driven approaches, whereas medical residents were less likely to believe template-based documentation improved their efficiency.⁴²¹ In a survey conducted by Medical Economics, it was observed that the choice of EMR did not correlate with specialty but that physicians customized EMRs to meet their specific needs.⁴²²

4.5.1.5 Practice Location

Practice location, at the regional level, had some correlation with adoption rates. Burt and Sisk⁴²³ found that adoption rates were somewhat higher in the Midwest (24 percent) compared with the Northeast (15 percent), the South (15 percent), and the West (19 percent). However, they found no association with urban or nonurban locations as defined by metropolitan statistical areas

(MSA). Although the authors do not speculate on why the Midwest has higher rates of adoption, there are factors identified in the literature that are relevant to the association between location and adoption.

Certain areas of the country have different physician reimbursement rates and different rates of managed care and HMO penetration, which was described previously.⁴²⁴ Likewise, costs of labor vary, and lower labor costs may blunt the benefit of expected labor savings with EHR adoption⁴²⁵ and may tip the cost-benefit calculus toward nonadoption. Social and professional networks can strongly influence physician adoption and practice behavior.^{426,427} Local leadership and experience with EMRs may influence the broader social and professional networks. Academic centers and delivery systems that are informatics thought leaders, such as the University of Indiana–Regenstrief, Harvard-Partners, and Intermountain Health Care Systems, may influence the local networks through leadership or by seeding the locality with their program graduates and physician affiliates. Likewise, grants and incentives to start regional health information organizations (RHIO) and other demonstration projects may seed localities with informatics pilots and facilitate the “infection” of local physician networks.⁴²⁸

Results of applicable studies are summarized in Exhibit 26.

Exhibit 26. Metropolitan or Regional Effects on Adoption Diffusion

Market Penetration	Burt and Sisk ⁴²⁹		Gans, et al. ⁴³⁰
	Metropolitan Status	Percent	Impact
Metropolitan Diffusion	MSA	17.5	NE
	Non-MSA	15.5	
Regional Diffusion	Region of U.S.	Percent	Impact
	Northeast	14.7	Minimal impact
	Midwest	23.7	
	South	14.6	
	West	19.1	

Legend: NE – characteristic not examined in survey

In Exhibit 27 we present a summary of the practice characteristics that affect adoption.

Exhibit 27. Summary of Practice Characteristics that Relate to EMR Adoption

Practice Characteristic	Burt and Sisk ⁴³¹	Audet, et al. ⁴³²	Gans, et al. ⁴³³
Size of Practice	+ (s)*	+ (s)*	+
Type of Practice ¹ (<i>Primary care vs. specialist</i>)	0	+ (s)*	NE
Scope of Practice ² (<i>Single vs. multi-specialty</i>)	0	NE	NE
Ownership of Practice ³	+ (s)*	NE	+
Source of Revenue (influence of different payors and managed-care contracts)	0	NE	NE
Mode of Compensation (<i>Salary vs. nonsalary</i>)	NE	+ (s)*	NE
Capitated Reimbursement	NE	NE	NE

Legend

NE	Characteristic not examined in survey	0	No correlation
+	Positive correlation, with no stat. significance	-	Negative correlation, with no stat. significance
+ (s)*	Positive correlation, with stat. sign. at 95%	- (s)*	Negative correlation, with stat. sign. at 95%

¹ Categorized by Burt and Sisk as "physician specialty" (primary care vs. surgical vs. medical, in which "primary care" includes family/general practice, geriatrics, internal medicine, pediatrics, and Ob/Gyn) and by Audet as "physician type" (primary care vs. specialist)

² Defined as the range of services (single vs. multi-specialty)

³ Grouped into three categories: physician/physician group, HMO, and other health care organizations. Data limited capture of dimension of HMO ownership to include capitation, comprehensive care, and insurance functions.

4.5.2 Physician Characteristics

In addition to practice characteristics, the survey literature has examined the relationship between individual physician characteristics and adoption of EMRs. These characteristics include age, gender, and physician specialty.

4.5.2.1 Age and Gender

Both Audet and Burt and Sisk found that differences in gender did not correlate with different rates of adoption. However, whereas Audet found that age did not correlate with adoption rates,⁴³⁴ Burt and Sisk found that physicians over 60 years old were less likely to adopt than younger physicians.⁴³⁵ The authors hypothesized that older physicians may be less comfortable with computers.

Also, there is evidence that older physicians are more resistant to change. Soumerai and colleagues found that they are less likely to change patient care practices even when presented with evidence that alternative approaches yield better outcomes.⁴³⁶

Age also appears to correlate with practice size (see Exhibit 28). Of the 136,669 solo practitioners identified in the AMA Physician Marketplace Report, 68,500, or 52 percent, were 55 or older.⁴³⁷ Only 22 percent of physicians working in practices of two to four physicians and 12 percent of physicians working in groups of five to nine physicians were 55 or over. Physicians under 40 were most likely to work in groups of two to four physicians (30 percent).

Exhibit 28. AMA Physician Marketplace Report: Age of Self-Employed Physicians⁴³⁸

No. Physicians in Practice	Under Age 40		Age 40–54		Age 55+		Total	
	No.	Percent	No.	Percent	No.	Percent	No.	Percent
1	14,437	24.7	53,732	32.6	68,500	52.1	136,669	37.3
2–4	17,501	30.0	48,441	26.9	28,480	21.6	94,422	25.8
5–9	10,601	18.2	29,374	16.2	15,279	11.6	55,254	15.1

Adapted from Kane, 2004

The correlation between age and solo practice, combined with the set of factors that may discourage adoption in older physicians, is consistent with Burt and Sisk’s observation that age over 60 is negatively correlated with adoption.⁴³⁹

Exhibit 29. Impact of Physician’s Age and Gender on EMR Adoption

Audet, et al. ⁴⁴⁰		Burt and Sisk ⁴⁴¹	
Age	Percent	Age	Percent
< 45	28.0	30–39	19.6
45–54	28.0	40–49	17.8
55–64	23.0	50–59	18.2
65+	26.0	60+	14.2
Gender	Percent	Gender	Percent
Female	25.0	Female	17.0
Male	27.0	Male	17.7

4.5.2.2 Specialty Type as a Physician Characteristic that May Correlate with Personality and Risk Appetite

Burt and Sisk found a correlation between specific specialties and adoption rates.⁴⁴² Orthopedic surgeons, cardiologists, and otolaryngologists had the highest rates of EMR use, whereas pediatricians, dermatologists, and psychiatrists had the lowest use rates. Greater financial resources may help overcome EMR cost barriers. Some specialties, particularly procedurally oriented specialties such as orthopedics, cardiology, and otolaryngology, command higher reimbursement rates and hence higher physician incomes.⁴⁴³

In addition to higher reimbursement rates, there are other factors that can help explain correlation between adoption and specialty. The Cloninger Inventory uses a typology that includes: novelty seeking, which predisposes one to take up new interests and make decisions more quickly; harm avoidance, which correlates with introversion; pessimism and worrying; and reward dependence, which correlates with eagerness to please others. Using the Cloninger Inventory, Vaidya and colleagues found that students choosing surgery, emergency medicine, and obstetrics and gynecology were higher on novelty-seeking than other students.⁴⁴⁴ Future surgeons were lower in harm avoidance, suggesting that they were less apt to worry. The attraction to new ideas, decisiveness, optimism, and lower tendency to worry resonates with Rogers’ description of a risk-taking innovator who is at the leading edge of technology adoption.⁴⁴⁵

In Exhibit 30 we present a summary of the physician characteristics that affect EMR adoption.

Exhibit 30. Summary of Physician Characteristics that Relate to EMR Adoption

Physician Characteristic	Burt and Sisk ⁴⁴⁶	Audet, et al. ⁴⁴⁷	Gans, et al. ⁴⁴⁸
Specialty (specifically defined)	+ (s)*	NE	+
Gender	0	0	NE
Age	0	0	NE

Legend: NE Characteristic not examined in survey 0 No correlation
 + Positive correlation, with no stat. significance – Negative correlation, with no stat. significance
 + (s)* Positive correlation, with stat. sign. at 95% – (s)* Negative correlation, with stat. sign. at 95%

4.6 Physician Perspectives on EMR Benefits and Barriers to Adoption

Unlike practice and physician characteristics, physician perceptions of costs, benefits, and barriers are modifiable. The technology diffusion literature suggests that these perceptions may be strongly influenced by peers and peer networks. They may also be amenable to influence by policy interventions, so physician perceptions are important to those who seek to influence physician behavior. In this section we rely heavily on the physician survey literature, in particular the five previously cited articles by Gans,⁴⁴⁹ Burt and Sisk,⁴⁵⁰ Audet,⁴⁵¹ Kibbe,⁴⁵² and the Medical Records Institute.⁴⁵³ We also draw on perceptions and adoption motivations cited by the 10 ambulatory Davies Award winners in 2003,^{454,455,456} 2004,^{457,458,459,460} and 2005.^{461,462,463}

4.6.1 Perceived Benefits

We have summarized perceived benefits and motivations driving EMR adoption based on relevant surveys and the Davies Award winners in Exhibit 31. Although the Davies Award data provide a more granular listing of benefits and motivations, they are not ranked or weighted, they represent a small sample size, and the benefit cited may have been articulated by only one practice. The surveys, on the other hand, provide large numbers of respondents and have ranked the relative importance of each factor. In both the surveys and case reports, physicians often cited clinical or patient care benefits more frequently than economic benefits. Common clinical themes included: improved workflow and efficiency, enhanced access to clinical information, and improved quality and safety. Gans specifically noted improved drug refill capabilities.⁴⁶⁴ The economic benefits included improved charge capture related to better coding and documentation. In addition, Gans noted reduced costs related to transcriptions and medical records maintenance, whereas the MRI survey cited a perceived competitive advantage achieved through adoption.⁴⁶⁵

Exhibit 31 shows net revenue enhancement as an important perceived benefit. The contribution to practice revenue enhancement came from decreasing costs and from increasing collections. Decreased costs were attributed to decreasing or eliminating costs associated with transcription and medical records maintenance, as well as savings associated with other labor efficiencies. Increased collections were associated with increased patient volume achievable with workflow efficiencies, increased charge capture per visit, and decreased denials due to improved documentation and coding.

A number of workflow efficiencies were noted, though more specific categories of efficiency were identified in the Davies Award responses. These included efficiencies related to prescription refills, access to information, patient scheduling, telephone communications, and insurance payment. Patient and staff satisfaction were also described as motivators by the Davies Award winners. However staff retention, an important issue in the hospital setting, was not emphasized by these respondents. Both improved efficiency and improved patient satisfaction may contribute to improved practice revenue through labor savings and increased volume, respectively. Improved practice and physician efficiency may generate benefit not just in income but in leisure time. Microeconomic models in which physicians maximize utility functions that include leisure have been used to model physician behavior.⁴⁶⁶

Exhibit 31. Summary of Expected Benefits of Adopting an EMR

Perceived Benefits of Adoption		Audet, et al. ⁴⁶⁷	Gans, et al. ⁴⁶⁸ (scale of 5)	MRI ⁴⁶⁹ (percent)	Davies Awards ^{470,471} 472,473,474,475,476, 477,478,479
Patient Safety and Quality	Improved Decision Making	+	4.15		
	Improved Access to Information	+	4.60		
	Reduced Medication Errors		4.19		
	Clinical Guidelines				+
	Improved Legibility and Data Capture			67.0	+
	Improved General Quality			86.1	
	Improved Patient Safety			69.6	
	Improved Clinical Decision Support			54.1	
	Increased Information Sharing			69.6	
	Increased Immunization Rates				+
Revenue Enhancement	Improved Charge Capture	+	4.16		+
	Improved Charge Quality with Documentation			78.4	
	Reduced Transcription Costs		3.92		
	Reduced Staff Expenses		3.96		
	Increased Patient Volumes				+
	Increased Physician Profit				+
	Improved Collection Rate				+
	Decreased Denials due to Coding Errors				+
	Elimination of Transcription Costs				+
	Decreased FTEs				+
	Creation of Competitive Advantage			60.3	
	Expanded Office Space				+

Perceived Benefits of Adoption		Audet, et al. ⁴⁶⁷	Gans, et al. ⁴⁶⁸ (scale of 5)	MRI ⁴⁶⁹ (percent)	Davies Awards ^{470,471} 472,473,474,475,476, 477,478,479
Efficiency	Improved Overall Workflow Efficiency	+	4.49	87.1	+
	Improved Drug Refills Capabilities		4.21		+
	Eliminated/Reduced Chart Pull: Instant Access to Charts				+
	Decreased Charting Time				+
	Patient Scheduling Efficiencies				+
	Decreased Insurance Turnaround Time				+
	Decreased Lab Results Reporting				+
	Increased Access to Patient Information				
	Decreased Phone Call Turnaround Time				+
Patient, Physician, and Staff Satisfaction	Increased Attention/Improved Customer Service				+
	Decreased Patient Wait Time				+
	Improved Practice Efficiency				+
	Improved Employee Retention				+
	Increased Time with Patient				+

Legend: + Positive correlation, with no stat. significance

4.6.2 Perceived Barriers to EMR Adoption

Using Bass macroeconomic diffusion models⁴⁸⁰ and historical adoption patterns, a recent study by Ford suggests that EHRs will not achieve full market penetration until 2024.⁴⁸¹ This timeline for widespread adoption varies significantly from the objective expressed by the President. Reasons for delayed adoption may relate to barriers that physician practices perceive. In Exhibit 32, we outline perceived barriers from the four surveys articles. We also include the results of semi-structured qualitative interviews performed by Miller.⁴⁸² Although each study approaches the issue of cost and affordability from a slightly different perspective, in all these studies cost and factors related to cost and affordability were consistently identified as significant barriers to adoption. Audet cites both startup and maintenance costs,⁴⁸³ Gans refers to the lack of capital resources,⁴⁸⁴ the AAFP survey highlights affordability,⁴⁸⁵ and the MRI survey describes EHR cost and lack of funding.⁴⁸⁶ In each of these, some measure of cost is consistently rated as one of the most significant obstacles, especially among physicians who have not adopted EHRs.⁴⁸⁷

Costs cited were not confined to the direct cost of the EMR but also to time devoted to various stages of the adoption process. For physicians, particularly self-employed, nonsalaried physicians, income is related to productivity or the number of patients they can see per unit time.⁴⁸⁸ Perceived costs related to choosing an EMR were therefore often expressed in terms of time.^{489,490} As suggested by Rogers, highly complex technologies such as EMRs require significant investments of time prior to purchase, and such complexity, and the time costs associated with it, can be barriers to adoption.^{491,492} Physician concerns regarding complexity not only are expressed in terms of evaluating and using the technology but also apply to other aspects of adoption, including such activities as developing an RFP or a contract. Each layer of

complexity has the potential to add cost, or perceived cost, from the physician’s perspective. In addition, productivity loss associated with the early stages of implementing and learning a new technology was cited as a significant barrier, especially among those who have not adopted an EMR.^{493,494}

Uncertainty regarding the costs and benefits of a technology can be a barrier to adoption.^{495,496,497} Uncertainty of future benefit or net benefit was cited in three surveys and was expressed as: “a lack of evidence of effectiveness,” “difficulty in building a business case,” or an inability to “see value.”^{498,499,500} Some respondents expressed a fear that the vendor may go out of business which is another source of uncertainty relevant to future costs and benefits.

Inadequate support from colleagues was highlighted as a concern in several of the studies,^{501,502,503} and among those who had adopted an EMR this was the most highly rated barrier cited in Gans.⁵⁰⁴ Miller observed that physician champions in these practices embodied the attributes of Rogers’ innovators, and early adopters and nonchampions were more easily discouraged.⁵⁰⁵ In his view, such champions were essential to success.

Exhibit 32. Perceived Barriers to Adopting an EMR, by Percentage of Respondents

Audet, et al. ⁵⁰⁶				Gans, et al. ⁵⁰⁷		
Barrier	Percent			Barrier	Mean Rating	
					Practice w/ EHR	Practice w/o EHR
Startup costs	56.0			Lack of support from practice physicians	3.32	3.15
Lack of uniform standards	44.0			Lack of capital resources to invest in an EHR	3.31	3.58
Lack of time	39.0			Concern about physicians’ ability to use EHR	3.18	3.40
Maintenance costs	37.0			Concern about loss of productivity	3.04	3.24
Lack of evidence of effectiveness	26.0			Inability to evaluate, compare, select EHR	2.60	2.86
Privacy concerns	21.0					
Lack of training	16.0					
AAFP, 2005 EHR Survey ⁵⁰⁸				Medical Records Institute ⁵⁰⁹		
Barrier	<10%	10–20%	>20%	Barrier	2003 (%)	2004 (%)
Affordability			+	Lack of adequate funding	64.2	55.5
Decreased productivity			+	EHR cost	32.3	36.0
Data entry cumbersome		+		Lack of support	37.2	35.4
Risk of vendor going out of business		+		EHR solutions that are fragmented	30.2	34.1
Lack of time		+		Creating a migration plan	29.2	27.6
Lack of expertise in selection		+		Meeting technical/clinical requirements	27.3	27.3
Partner acceptance		+		Inadequate health care information standards	22.9	27.3
Complex contracts	+			Difficulty in building a strong business case	21.9	24.7
Don’t see value	+			Difficulty in evaluating EHR solutions or components	17.2	23.1
Technology burdensome		+		Lack of structured medical terminologies	18.1	16.9
Mistrust of vendors	+					
Privacy	+					

Miller and Sim ⁵¹⁰	
<ul style="list-style-type: none"> • High cost and uncertain benefits • High initial physician time costs • Technology — poor usability • Difficult complementary (workflow) changes 	<ul style="list-style-type: none"> • Inadequate support • Inadequate data exchange with other systems • Lack of incentives • Physician attitudes

Legend: + Positive correlation, with no stat. significance

There are other barriers to adoption related to usability of the technology and its integration with workflow that act as barriers to adoption. Respondents to Gans' survey indicated that concerns over physicians' ability to use technology was one of the key barriers to adoption.⁵¹¹ The AAFP survey cited concerns over cumbersome EMR technology and associated difficulties in data entry.⁵¹² Rose and colleagues,⁵¹³ in citing Ash and colleagues,⁵¹⁴ state that physician resistance is often generated by a failure to integrate the technology with physician workflow. The survey conducted by Medical Economics found that physicians were more concerned with workflow features, costs, and ROI than with functions related to managing patient care.⁵¹⁵

Based on his findings, Miller suggested four overarching approaches to promote adoption.⁵¹⁶ These included: 1) programs and policies to support community-wide information exchange, 2) financial incentives such as pay for performance programs, 3) information for those considering purchase, and 4) support for the workflow and other complementary changes that must be made to maximize benefit from EMRs. Gans tested a number of these and similar suggestions by asking physician survey respondents about actions the government or private sector might take to overcome adoption barriers.⁵¹⁷ These actions included:

- ▶ Development of standardized questions to ask EHR vendors
- ▶ Model RFPs for EHRs and models for contracts
- ▶ Educational programs on how to select and implement EHRs
- ▶ Certification of EHR vendors
- ▶ Information on integration capabilities of EHR products with various practice management systems

Gans notes that each of these were ranked relatively highly, between 3.4 and 4.2 on a 5-point scale. The authors also asked groups that had already adopted an EHR what the impact of possible federal actions would be on the selection process. These included: direct financial assistance, rewards through pay for performance, establishing and publishing technology standards, and modifying the Stark laws to allow technology sharing. All of these were rated lower than the information-related actions suggested above, with rankings between 2.9 and 3.5 on a 5-point scale.

4.7 Technology Diffusion Literature

We have previously discussed factors that correlate with EMR adoption, such as practice size and ownership and physician age and specialty. However, it is important to assess these factors in the context of their relevance to *how* technology diffuses. In this section, we provide an overview of the literature relevant to the diffusion of EMRs. Because our goal is to create an economic framework for adoption of EMRs, the bulk of our review focuses on models from the

economics and marketing literature. We also review theories from other disciplines such as sociology and discuss their applicability to EMR adoption. Theories originating from the sociology literature, such as social network theory, appear to intersect with models from economics and marketing through epidemic effects that emphasize the importance of social networks in technology diffusion. The theoretical constructs reviewed in this section provided a foundation on which to construct an economic framework for adoption of EMRs in the ambulatory care environment.

4.7.1 Selected Theories of Technology Diffusion from the Economics and Marketing Literature

Within the economics and marketing literature, there are two fundamental approaches to explaining technology diffusion. One approaches the issue from an aggregate perspective and generates industry-level adoption curves (S-curves) that are not derived from individual adoption curves. In contrast, the microeconomic models of diffusion focus on the behavior of individuals or firms. These models generate individual adoption curves and allow one to isolate various factors affecting adoption by those individuals/firms. These curves can then be aggregated to derive industry-wide adoption curves. In this section, we review both classes of models and discuss their relevance to this study.

Economic models of technology diffusion may be related to a broad spectrum of “technologies.” An early contribution by Griliches (1957) examined the diffusion of hybrid corn among farmers.⁵¹⁸ He found that the rate at which innovation spread was related to the *cost* of absorption and the future *profitability* of the new technology. It was also related to the *similarity* between the new hybrid corn and the existing technology and market size (larger markets can provide economies of scale relative to cost of adoption). Early models of technology diffusion in the economics literature⁵¹⁹ relied on simple specifications, based on calculations of economic benefits and costs.

Although hybrid corn and EMRs represent very different technologies, any economic model that tries to explain adoption of a technology needs to incorporate the relevant costs and benefits associated with that technology. Our review of the survey literature has shown the importance of costs and benefits to physician adoption.^{520,521} In addition, factors such as similarity, identified by Griliches, may have relevance to EMR adoption. The dissimilarity between paper information systems and EMRs may be a factor that slows diffusion. The importance of *similarity* or *comparability* to adoption of technology is also stressed under sociological theories of diffusion.

Bass (1969) later described a diffusion model that relies on three fundamental parameters:⁵²²

- ▶ Market potential—the number of individuals who represent potential users of the product
- ▶ External influence—the impact of external factors such as use of advertising to influence adoption
- ▶ Imitation—the influence of “contagion” or word-of-mouth on adoption

The Bass framework belongs to a class of models called “epidemic models,” in which adoption spreads from one person to another in a manner analogous to the contagious spread of an infectious condition.⁵²³ In these models, the principal force driving adoption is the spread of information. The rate of information spread (contagiousness) drives the rate of adoption. Geroski describes an epidemic model in which costs and preferences of potential adopters have no impact on diffusion because they are assumed to be constant across all individuals.⁵²⁴ What varies among these individuals is the rate at which they receive information.

Epidemic models resonate with the social network theory embraced by Rogers⁵²⁵ (and others in the sociology literature) and is consistent with the observation that information relevant to technology adoption spreads through a variety of social networks. For example, in a study of EHR adoption at Beth Israel Deaconess Medical Center in Boston, Sands explored the informal network of primary-care physicians and their referral specialists.⁵²⁶ In this study, Sands hypothesized that referrals from primary-care physicians who use EHRs are a means for exposing specialists to EHR benefits and thus their use of this technology.

The macroeconomic classes of epidemic models represented by Bass do not provide a mechanism for examining individual decisions and do not take into account valuations of a technology that would be relevant to decision making. They do not explain why certain individual/firms are early adopters and others are late adopters, and they make it difficult to isolate factors relevant to firm-level adoption.

In constructing a framework that captures the forces influencing physician and physician practice behavior, it is more useful to apply microeconomic approaches that assume adopter heterogeneity. In this class of models, individuals assign different value to a technology based on expectations of cost and benefit. These differences in valuation could be driven by characteristics of the firm called “rank effects” such as practice size or ownership or, in the case of individuals, differences in risk preferences, age, or income.⁵²⁷ Costs of the new technology may be assumed to be constant or to decrease over time. An individual will adopt when his or her valuation exceeds the cost of adoption.⁵²⁸ These heterogeneity models are sometimes referred to as probit models or models that capture rank effects.

These rank or probit effects have been found to be relevant to EMR adoption. Audet,⁵²⁹ Burt and Sisk,⁵³⁰ and Gans⁵³¹ found that size, specialty type, ownership, mode of compensation (salary versus nonsalary), and region were correlated with adoption of an EMR. Although these rank effects may help explain adoption, they represent inherent characteristics of the practice that cannot be altered by policy interventions. It would be useful to explore other factors that can be affected by policy and that appear to be correlated with these rank effects. For example, with respect to EMRs, size may serve as a proxy for access to financial credit. One factor that may hinder adoption of technology, especially for small firms, is access to credit.⁵³² In the technology diffusion models we reviewed, borrowing constraints have not been explicitly incorporated. Given the findings of a Medical Records Institute study,⁵³³ it might be worthwhile to explore the relevance of financial constraints on adoption. It is important to examine models that incorporate factors other than rank effects in adoption of technology.

In addition to rank effects, Karshenas and Stoneman incorporated a variety of other factors to explain technology adoption at the microeconomic level,⁵³⁴ including:

- ▶ Stock effects—In a competitive market, adopters are more advantaged if competitors fail to adopt. The advantage is weakened as adoption becomes more widespread. Stock effects can be positive as well, where the benefits to adoption increase with the number of adopters.
- ▶ Order effects—There are persistent benefits from being an early adopter (i.e., timing of adoption determines valuation).
- ▶ Epidemic effects—Adoption spreads through contact with previous adopters (i.e., there is endogenous learning).

In this microeconomic approach, a firm's decision to adopt is based not only on the effects described above, but also on the firm's economic valuation of a technology under uncertainty. The applicability of stock and order effects is unclear in physician EMR adoption. We have found no strong evidence that patients choose physicians on the basis of whether they possess EMRs. However, if quality measures were accessible to patients and EMRs were important in both achieving and documenting a particular level of quality, EMRs could provide a competitive advantage. These measures of quality may become particularly important if pay-for-performance programs provide economic incentives to practices that are able to achieve high performance on quality measures. Anecdotal information from hospital chief information officers (CIOs) suggests that adoption is important to maintain a brand associated with excellence, particularly in academic centers. From their perspective, this cutting-edge image is important to convey to patients as well as potential physician recruits.⁵³⁵ On the other hand, there may be advantages to interoperability that accrue to physicians who care for patients in common. This would require broader rather than more limited adoption—suggesting positive stock effects.

Colombo and Mosconi enhanced the Karshenas and Stoneman model by including cumulative learning effects.⁵³⁶ These learning effects, which are relevant to the technology under consideration, accumulate over time. Such learning may lower the costs associated with adoption of a new technology, as the stock of human capital accumulated can make learning of a new technology less time intensive. For example, a physician resident with experience in using EMRs during his or her residency who joins a new practice can reduce the costs of adoption to that practice. Alternatively, practices that possess EMRs with a low level of functionality may be able to graduate to using EMRs with higher levels of functionality due to cumulative learning effects. Finally, physicians who have previously practiced in settings where there was a poorly implemented EMR may perpetuate a negative learning effect on their peers. These learning effects are applicable only when the new technology being adopted is similar to the existing technology, as described by Griliches.⁵³⁷

Although the models discussed above do exhibit variations in their choice of modeling approach, they share certain elements, including explicit accounting of costs and benefits, decision making about technology adoption in an environment where costs and benefits of that technology are

uncertain, and a micro-modeling approach that accounts for underlying differences in the population.

More recently, economists have used theories of options to model adoption of technology.⁵³⁸ In a seminal article by Jensen he describes a model in which the firm makes, in each time period, a decision regarding adoption (yes/no) and the timing of that adoption.⁵³⁹ The firm compares the expected profits from adoption with a given constant, fixed cost associated with the adoption. Expected profits are calculated based on an existing belief about the technology's contribution to profitability. In each time period, information regarding these expected benefits arrives in a random manner to the firm, which then updates its beliefs using the new information. The firm in each time period compares the value of adopting now versus deferring adoption. In Jensen's model, there are no costs associated with acquiring the information. Subsequent models have modified this assumption and have shown that when the cost of information acquisition is excessive, firms may delay adoption indefinitely.

Chatterjee and Eliasberg combined Jensen's approach with variations in individual preferences for risk when confronting uncertainty regarding the value of a new technology.⁵⁴⁰ In this microeconomic approach, individuals know the price of the new technology but may receive new information about the technology that can change their valuation. In the case of EMRs, this may relate to the functionality or usability of the product and the benefits these attributes will yield. An individual will adopt the new technology if valuation exceeds the price. Risk preferences of physicians are likely to cause variation in such parameters.

In contrast to the work of Jensen, Chatterjee, etc., Balcer and Lippman developed a model in which uncertainty was not related to the currently available technology but to the development of new technologies that may make current products obsolete.⁵⁴¹ Firms may delay adoption of a currently available new technology if they anticipate arrival of a superior product in the near future.

Models that account for timing of decisions, uncertainty, and the cost of information acquisition are relevant to the adoption of EMRs. There are different levels of uncertainty associated with adoption of EMRs. There is uncertainty related to future streams of costs and benefits but also uncertainty surrounding the state of the EMR technology itself. EMRs represent a relatively young information technology that, like other information technologies, can be expected to mature over time in both functionality and usability.⁵⁴² The expectation of rapid obsolescence or uncertainty regarding the pace of obsolescence may defer investment in an EMR. There is also evidence that the selection of an EMR is a complex choice, and this contributes to uncertainty of costs and benefits.⁵⁴³ The importance of complexity and uncertainty is also captured in the sociology literature, which we discuss in a later chapter of this document. In that paradigm, informal social networks may provide information that helps overcome uncertainty and other challenges posed by complex systems.⁵⁴⁴

All the models discussed above have several elements that appear to be relevant for adoption of EMRs:

- ▶ Valuation of technology in terms of costs and benefits
- ▶ Epidemic effects
- ▶ Rank effects such as size, location, age, etc.
- ▶ Stock effects (extent of adoption within the market)
- ▶ Order effects (advantages of early adoption)
- ▶ Cumulative learning effects
- ▶ Uncertainty associated with value and state of a technology
- ▶ Value of information

4.7.2 Social Network Theory of Technology Adoption

Leveraging early work by French sociologist Gabriel Tarde (1903), who first described the S-shaped adoption curve,⁵⁴⁵ Ryan and Gross modeled the adoption of hybrid seed corn in Iowa in the 1940s.⁵⁴⁶ They found that peer influences among farmers helped explain the adoption of the new technology. Whereas Griliches emphasized the importance of cost, profitability, and similarity to previous technologies,⁵⁴⁷ Ryan and Gross emphasized the importance of social networks. Coleman analyzed tetracycline adoption by physicians and noted that the size and characteristics of a physician's interpersonal network were key factors in the diffusion of tetracycline prescribing behaviors.⁵⁴⁸ A fundamental difference between prescribing a new drug and adoption of EMRs is that the former does not require substantial capital investment by the physician as does an EMR. These studies led to the development of a more robust theory of social networks to explain technology diffusion.^{549,550}

One of the major theories of technology diffusion that emerged from the sociology tradition was formulated by Rogers.⁵⁵¹ Others, such as Miller and colleagues⁵⁵² and Bower,⁵⁵³ have used the Rogers framework to conceptualize different aspects of EMR diffusion. Rogers describes his theory of diffusion of innovations by defining four primary elements:

- ▶ Innovation
- ▶ Communication channels
- ▶ Time
- ▶ Social system

Each of these elements are further associated with certain attributes and likelihood of technology adoption that is determined by how individuals perceive or experience these attributes. Attributes related to innovation have been cited by others as relevant to EMR adoption.⁵⁵⁴ These include:

Relative Advantage: The degree to which an innovation is perceived as better than the idea it supersedes. In the case of hybrid corn, the standard of comparison is prior strains of corn. In the case of EMR, it is paper charts. The greater the perceived relative advantage of an innovation, the more rapid its rate of adoption.

Compatibility: The degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters. This is analogous to the concept of similarity articulated by Griliches.⁵⁵⁵ In the case of EMR, this may relate to

perceptions of how this tool will change work processes and how physicians will take care of patients.

Complexity: The degree to which an innovation is perceived as difficult to understand and use. New ideas that are simpler to understand are adopted more rapidly than innovations that require the adopter to develop new skills and understandings. EMRs are complex technology systems with different levels of functionality and usability. Such complexity contributes to barriers on multiple levels.⁵⁵⁶ The time and costs associated with unraveling that complexity can be considerable. Complexity also contributes to uncertainty and the level of confidence that one has made the correct decision. Information gleaned through peer networks and imitation of peer behavior are ways of coping with complexity and potentially lowering costs and uncertainty associated with decision making in that environment.

Trialability: The degree to which an innovation may be experimented with on a limited basis. An innovation that is trialable represents less uncertainty to the individual considering it for adoption. An EMR system implementation, unlike a cell phone, PDA, or e-mail account, represents a major commitment of resources and is not conducive to trial periods. However, this complexity makes it even more important for prospective adopters to try the technology to minimize the uncertainty associated with choosing complex systems. Individuals who have used EMRs in other settings, such as in their residency training program, VA hospital, or the hospital with which they are currently affiliated, have had the opportunity to try a version of the technology. The ability to test and evaluate the technology in a previous setting may lower barriers to adoption in the office setting. Trialability contributes to the cumulative learning effects modeled by Colombo and Mosconi in the economics literature.⁵⁵⁷ Another approach to increasing the trialability of EMR, appropriately dubbed the “sandbox,” was developed by the AAFP through its EMR Pilot Project. The AAFP provided potential users with a test system (the sandbox) that allowed physicians to try different software applications and load dummy data into the test system prior to implementation. The authors of the AAFP report indicated that the sandbox provided users with a valuable educational vehicle that enhanced user buy-in and adoption.⁵⁵⁸

Observability: The degree to which the results of an innovation are visible to others. The easier it is for individuals to see the results of an innovation, the more likely they are to adopt it. Observability, like trialability, provides the potential adopter with more direct evidence of the benefits of a new technology, thereby reducing the uncertainty associated with a complex, expensive purchase. A physician’s social network may be a valuable source of observation opportunities that would allow the physician to see how an EMR supports the care of patients and affects the workflow of physician colleagues.

According to Rogers, innovation/diffusion is also affected by the underlying characteristics of the individual.⁵⁵⁹ Some of these characteristics can be mapped to the rank effects specified in the economics literature. For example, references to or attitudes toward risk represent rank effects. Rogers classifies adopters into the following categories and identifies characteristics associated with these types of individuals that can help explain adoption:

- ▶ Innovators—are interested in new ideas; risk-takers; have a high tolerance for uncertainty
- ▶ Early adopters—are members of a peer network; are regarded as opinion leaders
- ▶ Early majority—are members of a peer network but are not considered opinion leaders
- ▶ Late majority—are driven to adopt by economic need and peer pressure; have a cautious approach to adoption
- ▶ Laggards—are suspicious of innovations and change agents; rely on past experience to guide future choices

Rogers' and other social network models of diffusion intersect with the economics literature. They both stress the importance of information in the adoption of technology. The potential to lower costs of information acquisition may be particularly important in making decisions relevant to complex technologies such as EMRs. Ford conducted an analysis of the survey literature pertaining to physician adoption of EMRs with the intent of estimating the possibility of the United States reaching national EHR adoption by 2014.⁵⁶⁰ The results of this study conclude that the current rate of office-based EMR adoption among physician practices of less than 10 physicians is 18.325 percent, based on the survey literature examined. Some Ford's explanations for this adoption rate include noting that "physicians have historically relied on their professional peers as their primary source of information related to new technologies." Ford asserts that the medical community may view EMRs based on the social mechanisms that influence adoption decisions. An economic framework of EMR adoption needs to include the role that information plays in the decision to adopt.

4.7.3 Models of Technology Diffusion—An Application to EMRs

There is a very limited body of literature that specifically examines EMR diffusion in the context of the theoretical models we have discussed above. All of the EMR analyses we identified were based on macroeconomic epidemic models or social network constructs, such as Rogers.⁵⁶¹ Our literature review has not yielded to date microeconomic models of physician-level EMR adoption.

Using the construct of social network theory, Ford developed a model to predict the adoption of EMRs by physicians in small practices (10 or fewer).⁵⁶² The study used adoption data obtained from previously published surveys in their model. The mathematical specification of industry-wide adoption of EMR in the study was based on the Bass diffusion model. The authors chose values for the coefficient of innovation (which captures the tendency to adopt) and the coefficient of contagion to fit the Bass model to historical adoption data from the survey literature. Using the fitted Bass model, they predicted rates of EMR adoption up to 2024.

An early paper by Anderson and Jay (1985) focused on the role of physician networks in promoting physician adoption of EMRs in the hospital environment.⁵⁶³ Adoption here does not refer to acquisition of new technology by physicians but rather to physician use of an existing hospital information system. Their findings stressed the importance of the following variables on physician use of new technology:

- ▶ Presence of informal communication networks
- ▶ Network location

- ▶ Epidemic effects—Adoption occurs through contact with other adopters.

Although they found that peer effects had a strong influence on physician EMR use, there are some important differences between this paradigm and physician adoption in the office setting. In the latter case, the physician faces a significant investment decision that he/she doesn't face in a hospital environment. Physician EMR adoption, or rather use, in the hospital environment is more analogous to the adoption or use of new drugs, as described by Coleman, as in both cases the physician is not required to make a significant investment of financial capital.⁵⁶⁴

England and colleagues examined the factors that can explain the slow rate of HIT adoption through use of innovation diffusion theory.⁵⁶⁵ In this study, the authors place adoption of HIT within the Rogers innovation framework and draw upon the variables from Rogers' framework to gain insights into current HIT adoption. In their view, the primary reasons for the slow rate of HIT adoption include providers' fragmented internal structure, immature status of strategic HIT, constrained financial resources, and complexity of HIT systems. Although placing HIT adoption within Rogers' framework does provide some insights, the authors of this study do not test the predictive capability of their HIT framework.

Borzekowski explored hospital adoption of HIT focusing on the link between financing of health care and adoption of hospital information systems (HIS).⁵⁶⁶ Borzekowski models adoption of HIT under a discrete hazard model framework. In this approach to modeling adoption, the focus of the study is not on the timing of adoption but on the presence or absence of systems. Borzekowski estimates probabilities of adoption using a statistical model with regulatory and finance variables as covariates. This type of technology adoption modeling approach is useful for examining discrete events rather than for investigating factors that affect the timing of adoption. However, the focus on hospital systems makes it less relevant for our purposes.

In related literature, Cain and Mittman examined adoption of medical innovations by physician practitioners.⁵⁶⁷ Their study identifies 10 factors that can affect the diffusion of new medical technologies such as CT scans and EMRs. The critical factors they identify coincide with the framework introduced by Rogers. Although their study highlights factors that can impact adoption and therefore diffusion of new technology, it does not provide guidance on the mathematical characteristics of these factors and their relative importance with respect to explaining adoption.

Bower developed a framework or model that can help predict the trajectory of future EHR diffusion, though his model was not specifically focused on the physician office setting.⁵⁶⁸ Bower used existing diffusion theories, examined diffusion curves of other technologies and industries, and derived an industry-wide EHR diffusion curve based on these historical observations. The model used a standard "epidemic" diffusion equation, described as follows:

$dN(t)/dt = (a+bN(t)) (m-N(t))$, where:

- $N(t)$ is the proportion of total potential adopters at time t
- a is a coefficient of external influence (vendors, marketing, government publicity)
- b is a coefficient of internal influence/imitation (captures the influence of other adopters, which drives epidemic effects)
- m is the proportion of potential adopters that will ultimately adopt

Bower gathered qualitative data to assign values to a , b , and m in the above equation. Using parameters that relied heavily on Rogers’ construct, he ranked key attributes of EHR such as relative advantage and complexity, as well as the other variables listed in Exhibit 33.

Exhibit 33. Relevance of Diffusion Variables for EHRs⁵⁶⁹

Causal Diffusion Variables	Relevance to EHR Diffusion
Relative advantage to clinicians	High
Compatibility with existing systems	Moderate
Complexity of the system	High
External influence	Low
Social pressure	Moderate to high
Network effects	High
Specialization	Low to moderate
Government policy	Moderate

Having established the characteristics of EHR diffusion as depicted in Exhibit 33, Bower sought out another technology that had similar rankings in these categories. Based on these criteria, he selected large-scale relational databases (LSRD) as an analogous technology. Then, using diffusion curves for LSRDs described by Teng and colleagues,⁵⁷⁰ he “fitted” the EHR curve and found a reasonably good match. This curve projected a current EHR adoption rate of about 30 percent.

As the author did not focus on the ambulatory environment, findings of this study are more consistent with hospital adoption rates. Adoption rates in small physician offices are substantially lower, approximately half.^{571,572,573} In addition, this provides a macroeconomic industry-wide perspective that does not model individual physician or physician practice behavior. This approach does not provide insight into “levers” that policymakers would pull to influence adoption at the physician office level.

Based on a review of the general technology diffusion literature and EMR diffusion literature in particular, the following overarching observations emerge:

- ▶ The economics literature and social network theory both identify physician networks as relevant to adoption behavior.

- ▶ There are microeconomic approaches to modeling technology diffusion that have relevance to EMR diffusion.
- ▶ There is currently a lack of robust microeconomic models that have been developed that explain the nature of EMR adoption and diffusion at the physician practice level.

4.8 Current EMR Initiatives

In previous sections, we presented factors that correlate with physician adoption of EMRs. We reviewed, in particular, a number of factors that hinder physician adoption. In this section, we highlight current EMR-related programs and initiatives that aim to address some of the barriers previously described. We focus on efforts by the Federal Government, health plans, and foundations that have widespread reach and access to ambulatory care physicians, whether through purchasing power or other means of influence. There is growing emphasis on EHRs at the federal level since the President issued an executive order in 2004 announcing the goal of widespread EHR adoption in 10 years.⁵⁷⁴

This section provides a representative sampling of current programs and initiatives. Although these programs and initiatives may be grouped in a variety of ways, we will present them in three categories: 1) community-focused initiatives, such as the Agency for Health Care Research and Quality's (AHRQ) HIT-focused grants; 2) physician-focused initiatives, such as pay-for-performance programs; and 3) standards-focused initiatives like the e-prescribing standards promoted by the Secretary of the Department of Health and Human Services (HHS) as part of the Medicare Prescription Drug Benefit Program. These programs may be influenced through a variety of mechanisms which at the most fundamental level can be categorized into financial support, information support, and legislative or regulatory mandates.

- ▶ Financial support—As noted earlier, financial barriers are perceived by physicians as the most significant hurdle to adoption. Financial support may be offered in the form of grants or through pay-for-performance demonstration programs aimed at a community, in which physicians are one of many stakeholders, or directly aimed at physicians. In either case, such support may lower physicians' cost of implementation. Once implementation is achieved, it may generate a positive outcome or experience which, in turn, may influence other physicians through the epidemic effects of information flow.
- ▶ Information support—The lack of reliable information and time costs associated with acquiring product information is also a significant barrier to adoption. Some programs, such as the Centers for Medicare and Medicaid Services' (CMS) Doctor's Office Quality — Information Technology (DOQ-IT) project, are aimed at providing physicians with information to ease the selection of EMRs. Other programs provide information through funded demonstration projects.
- ▶ Legislative and regulatory mandates—The Government may also influence both the adoption of standards and the adoption of EHR through legislative and regulatory authority. The Medicare Modernization Act of 2003 (MMA) has facilitated the

development of e-prescribing standards by requiring their development. Similarly, the MMA included several provisions establishing a number of demonstration projects and pilot programs to test new payment mechanisms that either tie physician reimbursement to, or encourage, the use of HIT in practice as part of a broader goal to improve health care quality and outcomes.

The Kinds of Agencies and Organizations Reviewed

As the largest single payor of health care services, the Federal Government has significant market power and is a catalyst for promoting the adoption and implementation of EMRs in ambulatory care settings. The HHS and its operating divisions and offices, especially the AHRQ, CMS, Health Resource Services Agency (HRSA), and Office of the National Coordinator for Health Information Technology (ONC) have programs relevant to EMR adoption as part of broader set of quality of care initiatives. In addition, the Department of Defense (DoD) and Department of Veterans Affairs (VA) have been institutional early adopters of EMRs.

Foundations like the e-Health Initiative Foundation and the California Health Care Foundation have been instrumental in providing grants for the development of community-wide data exchange networks (which may include physician acquisition of EMR systems); HIT training programs for clinicians; and resource centers that provide reports and materials that address lessons-learned from existing HIT programs, as well as implementation roadmaps to help those contemplating adoption navigate the complexities of the adoption process. In addition, the Markle Foundation, in collaboration with the Robert Wood Johnson Foundation, has created a project called Connecting for Health, which is a public-private collaborative concerned with HIT connectivity and information exchange. They have been awarded funding by the Federal Government to develop prototypes for health information exchange on a statewide basis.

Physician organizations, like the AAFP and AMA, provide physicians with information about the cost and benefit of EMRs for their particular specialty, develop resources to guide physicians in the purchasing process, represent the physician's voice in HIT policy discussions and public/private partnerships, and develop specialty-defined EMR templates. A number of health plans have also developed pilot programs to stimulate adoption of HIT among physicians.

Most efforts sponsored by these agencies and organizations are in their early stages of implementation and have not been evaluated for impact. However, over time, they will provide useful information and lessons-learned about the optimal approaches to facilitate EMR adoption in a manner that promotes higher quality and more cost-effective care.

4.8.1 Community-Focused Programs

Community-focused programs are generally aimed at a broad spectrum of stakeholders including physicians. Although these programs often focus on collaboration, information sharing, and governance, they also provide support for adoption of HIT. Physicians may benefit directly through financial or information support or indirectly through the accumulated learning that these community-focused programs generate.

4.8.1.1 AHRQ—Building the 21st Century HIT Infrastructure

The purpose of this funding opportunity is to help communities, hospitals, providers, and health care systems plan, implement, or demonstrate the value of HIT. There are three main funding opportunities:

- ▶ Transforming Healthcare Quality through Information Technology—Planning Grants
- ▶ Transforming Healthcare Quality through Information Technology—Implementation Grants
- ▶ Demonstrating the Value of HIT Grants

Over 100 grants have been awarded to date, totaling \$96 million for all three projects. The planning grants support the development of a HIT infrastructure and data-sharing capacity among clinical provider organizations of a community. Planning grants allow communities to conduct needs assessment studies, develop plans to implement EMRs, create systems for patient data sharing, build telehealth and telemedicine systems, and create systems that enable point-of-care access to patient information and treatment guidelines. The implementation grants support community-wide and regional HIT systems, and the grants for demonstrating the value of HIT focus on how the adoption and use of HIT can improve patient safety and quality of care. Specifically, the value demonstration projects evaluate the impact of HIT adoption on quality, safety, and resource use in large integrated delivery systems; the effectiveness of web-based patient education tools; and the quality of patient transitions between health care facilities and home.⁵⁷⁵

This AHRQ grant program, and programs like it, illustrate how an initiative may influence EMR adoption in a variety of ways. When physician offices are among the grantees, the financial support may lower the cost of EMR acquisition, implementation, or connection to other systems. By exposing more physicians and physician networks to EMRs, valuable information about the utility of such systems can be shared. The opportunity to observe and try a technology is important in promoting its adoption.⁵⁷⁶ The HIT impact evaluation grants provide financial support to build the evidence base for the efficacy of EMRs in promoting the quality of care. This evidence, in turn, builds the information base from which physicians can learn. Finally, by distributing these grants across a broad number of communities, localities are seeded with EMR projects—the impact of which may influence local physician peer networks.

4.8.1.2 National Resource Center for Health Information Technology

The National Resource Center for Health Information Technology (hereafter, the National Resource Center) was established through grant funding from AHRQ totaling \$18.5 million. The National Resource Center is based at the National Opinion Research Center at the University of Chicago. It serves as the central repository for the research findings of the AHRQ-funded HIT projects to facilitate more effective dissemination of lessons-learned and begin to translate research into practice. It also provides direct technical assistance and consulting services to the AHRQ HIT projects.⁵⁷⁷ The information, education, and support this program supplies to the broader community may also be of value to physicians implementing systems or contemplating implementation.

4.8.1.3 Healthy Communities Access Program

Another example of a community-focused grant that includes practicing physicians is HRSA's Healthy Communities Access Program (HCAP). HCAP was established in 2002 under Section 340 of the Public Health Service Act. Its focus is to improve and strengthen community health care delivery systems that coordinate and provide care for uninsured and underinsured individuals. Communities and consortia of health care providers, including federally qualified health centers, hospitals, public health departments, and public- or private-sector health care providers that serve the medically uninsured and underserved, are eligible to apply for the funding. HCAP supports information sharing, clinical and financial coordination among providers, and systems of comprehensive and coordinated health care services. The goal is to achieve higher quality of care for the uninsured and underinsured and to lower health care costs, particularly for individuals with chronic conditions.⁵⁷⁸ Although HCAP is focused on improving the quality of care among the targeted populations, funds can be used to deploy HIT systems that help coordinate care and make the delivery of their care more efficient. Some HCAP grantees have used the funding to implement EMRs to make patient information available to all providers in the system.⁵⁷⁹

4.8.1.4 Connecting Communities for Better Health

Foundations whose mission is to improve health care in the United States have also been instrumental in providing grants that promote the adoption and use of HIT to physicians and their communities. One such foundation is the e-Health Initiative Foundation. In 2004, the e-Health Initiative Foundation provided a total of \$2 million in seed funding to nine multi-stakeholder collaboratives using electronic health information exchanges and other information technology tools to drive improvements in health care quality, safety, and efficiency in their communities. The collaboratives include:

- ▶ Denver, CO—Colorado Health Information Exchange
- ▶ Indianapolis, IN—Indiana Health Information Exchange
- ▶ Waltham, MA—Massachusetts—SHARE MedsInfo e-Prescribing Initiative
- ▶ Baltimore-Washington DC metropolitan area—Collaborative for Healthcare Information Technology
- ▶ Santa Barbara, CA—Santa Barbara County Care Data Exchange
- ▶ Fishkill, NY—Taconic Health Information Network and Community
- ▶ Kingsport, TN—CareSpark Tri-Cities Tennessee/Virginia Care Data Exchange
- ▶ Bellingham, WA—Whatcom County e-Prescribing Project
- ▶ Milwaukee, WI—Wisconsin Health Information Exchange⁵⁸⁰

The purpose of these grants is to design and develop health information exchange networks and are aimed at community stakeholders, including health care providers, health departments, state and local government, employers, and industry (e.g., pharmaceutical developers). Multi-stakeholder partnerships are encouraged to apply for these grants.

Some of these projects include connectivity to physicians in ambulatory care settings. For example, the CareSpark Tri-Cities project—a community-based approach to health improvement—aims to connect small physician practices treating a mostly rural population located within a 16-county, multi-state area. The CareSpark Tri-Cities project will focus on medication and diagnostic improvement, preventive medicine, and chronic disease management for targeted conditions that affect the region most: diabetes, cardiovascular disease, hypertension, asthma, and immunization. As part of its efforts, the community collaboration will employ EMRs and evidence-based guidelines to bring decision support at the point of care and exchange of health information among multiple providers to ensure coordination of care.⁵⁸¹

Similar to the CareSpark Tri-Cities project, the Whatcom County e-Prescribing project will connect six primary-care and specialty physician practices and one hospital and pharmacy through the use of a computer-based e-prescribing software system and PDAs. The e-prescribing system is connected to SureScripts, establishing the physician pharmacy connector, and to RxHub, the system used by the largest pharmacy benefit payor in the community. The goal will be to make formularies available at the point of prescription for a majority of the patients, electronically transmit prescriptions directly to pharmacy systems, and have a single viewing of a patient's medication list available across all participating providers.⁵⁸²

4.8.1.5 Connecting Communities for Better Health Resource Center and Learning Forum

The eHealth Initiative Foundation, in partnership with the HRSA Office for the Advancement of Telehealth, launched the Connecting Communities for Better Health (CCBH) Resource Center in 2004 to develop, share, and disseminate knowledge, resources, and tools to facilitate and support community-based health information exchange. The Resource Center compiles tools, resources, and lessons-learned from the grantees of the CCBH program.⁵⁸³

The eHealth Initiative also hosts an annual CCBH Learning Forum to showcase the efforts and progress of the CCBH grantees. The CCBH Learning Forum brings together a multitude of diverse stakeholders interested in furthering EMR and other HIT systems dissemination and use. In these Learning Forums, stakeholders:

- ▶ Identify common principles and strategies around clinical, financial, legal, organizational, and technical implementation issues with the goal of furthering HIT system dissemination
- ▶ Use case studies and in-depth discussions to educate and share tools with communities to promote health information exchange and identify practical approaches to address common challenges
- ▶ Facilitate the development of collaborative relationships among various stakeholders at the national, regional, and local levels⁵⁸⁴

As previously discussed, there is uncertainty with regard to financial cost, financial benefit, product reliability, standards, the purchase processes, implementation, and risk associated with adoption, among others. Efforts that consolidate lessons-learned and provide information about EMRs to physicians contribute to reducing uncertainty in the procurement decision.

4.8.1.6 Medicare Health Support Program

Another community-focused intervention is the Medicare Health Support Program. It was formerly known as the Voluntary Chronic Care Improvement Programs Initiative that was authorized by Section 721 of the MMA of 2003. The initiative calls for the phased-in development, testing, evaluation, and implementation of regional voluntary chronic care improvement programs. The purpose of this initiative is to help 150,000 to 300,000 eligible Medicare beneficiaries better manage their chronic disease through guidance and self-care support. It also aims to help Medicare beneficiaries coordinate their medical care.⁵⁸⁵ Payment is tied to outcomes, and the Chronic Care Improvement Organizations are responsible for improving clinical quality of care, improving beneficiary and provider satisfaction, and achieving savings targets.⁵⁸⁶ Eligible organizations include physician group practices, disease management organizations, health insurers, integrated delivery systems, a consortium of these entities, and other legal entities that the HHS Secretary approves.

The program requires participating organizations to “use decision support tools such as evidence-based practice guidelines or other criteria as determined by the Secretary; and develop a clinical information database to track and monitor each participant across settings and to evaluate outcomes.”⁵⁸⁷ There was specific mention of HIT in the CMS RFP for the pilot program, and applicants were able to propose any strategy they believed would help them achieve the performance targets for quality, satisfaction, and savings.⁵⁸⁸ Inclusion of the use of HIT in an applicant’s proposal was desirable, and if selected to be one of the awardees, Medicare will pay the PMPM fee proposed by the applicant, which would include covering the cost of acquiring EMRs or other HIT systems.⁵⁸⁹ The program is currently a 3-year pilot, but any programs or program components deemed successful by the HHS Secretary are to be expanded, possibly nationwide.⁵⁹⁰

Phase I is currently underway, and eight regions are operational as of January 2006: Oklahoma, Western Pennsylvania, Washington DC/Maryland, Mississippi, Chicago, Central Florida, and Tennessee.⁵⁹¹

4.8.2 Physician-Focused Initiatives

Although some physician-focused initiatives have a community-wide dimension, there is, relatively speaking, a greater emphasis on physicians and providers. Examples include demonstration projects like the CMS’s pay-for-performance initiatives and the private sector’s Bridges to Excellence program. These demonstration programs offer financial incentives directed toward encouraging providers to use EMRs and other HIT to achieve the broader goal of improving health care quality. These initiatives promote adoption of EMRs by testing innovative payment mechanisms that begin to align financial incentives between different stakeholders involved in the delivery of health care services.

Some physician-focused interventions may be indirect subsidies for physician acquisition of EMR systems. The Bridges to Excellence program and the Medicare Care Management Demonstration are examples of indirect subsidies. In contrast, some health plans like Blue Cross

Blue Shield of California and Massachusetts have provided direct investment on behalf of physicians to acquire EMRs and e-prescribing systems.

4.8.2.1 Bridges to Excellence

The Bridges to Excellence initiative created by physicians, employers, health plans, and patients is an example of a physician-focused initiative. The initiative employs a pay-for-performance strategy to begin re-aligning incentives around producing higher quality of care and, in turn, providing indirect subsidies to physicians for acquiring EMR systems. Bridges to Excellence is composed of three main programs: Physician Office Link, Diabetes Care Link, and Cardiac Care Link.

The Physician Office Link is the program most relevant to this study. It provides physician offices with bonuses based on their implementation of specific processes to reduce errors and increase quality. The practices are assessed based on their performance in areas of clinical information systems, patient education and support, and care management. The physician practice will be assessed on how it uses information to track patients' treatment, follow up on tests, check medications, and use evidence-based medicine. Each practice can earn up to \$50 per year for each patient covered by a participating employer or plan. A report card for each physician office describing its performances on program measures will be made available to the public through the National Committee on Quality Assurance's web site.^{592,593,594} The National Committee on Quality Assurance will conduct program evaluations for each of the three Bridges to Excellence programs.

The Diabetes Care Link allows eligible physicians to receive up to \$80 for each diabetic patient covered by a participating employer and plan. In this program, physicians may apply to obtain a 1-year certification by submitting data on HbA1c, blood pressure, and lipid testing for their diabetes patients; or for 3-year recognition for high performance in diabetes care by submitting data on eye, foot, and nephropathy exams that are additional to the 1-year certification requirements. The Cardiac Care Link provides eligible physicians with a higher bonus for their performance—up to \$160 for each cardiac patient covered by a participating employer and health plan. Similar to the Diabetes Care Link, there is a set of process and outcomes measures developed by the National Committee on Quality Assurance to determine performance of each physician practice. The cost of running these two programs to participating employers is \$200 or less per patient per year (\$175 for Diabetes Care Link and \$200 for Cardiac Care Link). Savings that accrue to the employers are estimated at \$350 per diabetic patient per year and \$390 per cardiac patient per year.⁵⁹⁵

4.8.2.2 Medicare Care Management Demonstration Program and Doctor's Office Quality—Information Technology Project

Another physician-focused initiative is the Medicare Care Management Demonstration Program, mandated by Section 649 of the MMA of 2003. It is a 3-year pay-for-performance program, modeled after Bridges to Excellence. The program's purpose is to promote the adoption and use of EMRs and other HIT to improve care management practices.⁵⁹⁶ This demonstration program will provide physicians with incentives for adoption and use of HIT to manage the clinical care of eligible Medicare beneficiaries and to provide electronic reports of clinical quality and

outcomes measures established by the HHS Secretary. An initial set of quality measures focus on five major conditions: coronary artery disease, diabetes, heart failure, hypertension, and preventive care.⁵⁹⁷ Physicians who meet or exceed the performance standards in clinical delivery systems and patient outcomes will receive bonus payments in a per-beneficiary amount.⁵⁹⁸ The demonstration is taking place in four states: Arkansas, California, Massachusetts, and Utah. The Medicare Care Management Demonstration Program is an example of an incentive program that provides direct financial support to physicians. Although the goal is to improve the quality of care, achieving that goal and documenting it with data would be difficult without an EMR

The Medicare Care Management Demonstration Program is linked to another CMS initiative called the Doctor's Office Quality—Information Technology (DOQ-IT) project. CMS has partnered with the Quality Improvement Organizations (QIO) in each of the demonstration sites to provide technical support for the program and help the sites with the selection and implementation process involved in the adoption of EMRs. CMS has expanded nationwide its partnership with the QIOs. As part of the DOQ-IT project, all QIOs in the United States are charged with the responsibility of promoting the adoption and use of EMRs and other HIT in small- to medium-sized physician practices.⁵⁹⁹ Furthermore, CMS has partnered with the AAFP to further its ability to reach out to primary-care providers on issues related to HIT adoption.⁶⁰⁰

The DOQ-IT program is an example of a program that primarily uses information to promote adoption of EMRs. It addresses concerns raised by physicians regarding the complexity and uncertainty associated with selecting an EMR product. By providing information and support, this program may lower the time costs associated with EMR selection.

4.8.2.3 Selected Blue Cross Blue Shield Programs

In contrast to the Bridges to Excellence program and the Medicare Care Management Demonstration Program, private-sector payor initiatives provide direct subsidies to physicians to help them purchase and implement EMR systems. For example, Blue Cross Blue Shield of California provided 25,000 of its contracted physicians with the choice of a desktop computer or a handheld device. Though these items were offered to physicians free of charge, only one in four of the physicians accepted them. This \$42 million incentive program yielded disappointing results and prompted Blue Cross Blue Shield CEO Leonard Schaefer to comment that “free was not cheap enough.”⁶⁰¹ This underscores the notion that interventions must be designed in a way that integrate with physician workflow and account for the time costs associated with training and change management. Although demonstration projects have the potential to promote adoption, negative outcomes may also impede adoption.

In another experiment, Blue Cross Blue Shield of Massachusetts plans to invest \$50 million to fund the adoption of EMR by physicians and hospitals in three geographically disparate communities in Massachusetts. The program will include approximately 500 office-based physicians who will receive a subsidy of approximately \$40,000 each. These funds are intended to cover the cost of hardware and software as well as training and change management.^{602,603,604} Because the evaluation component is intended to have a pre/post-implementation design that includes quantifiable costs and benefits, it has the potential to add significantly to the body of research relevant to costs and benefits of EMR implementation in the ambulatory setting. It is

also likely to have significant impact on physician peer networks, either positively or negatively, in that region of the country.

4.8.2.4 Veterans Health Information Systems and Technology Architecture Adapted to Civilian Physician Offices

The VA and CMS have made several significant attempts to provide a modified version of the VA's VistA EHR software to non-VA practicing physicians, particularly physicians working in clinics and small practice settings. The VA began computerizing care in its facilities in 1985. The automated information system at the time was the Decentralized Hospital Computer Program, which evolved into the VistA in 1996. The EHR component of VistA is the Computerized Patient Record System (CPRS), which integrates the clinical data from VistA into a complete EHR for inpatient and outpatient settings. CPRS has functional capabilities such as reminders and allows for instant communication between providers.⁶⁰⁵

In the past, the VA has partnered with CMS to provide a version of VistA to non-VA physician practices. The VA has made its older VistA product available to clinics and physicians, but it was difficult to install and use.⁶⁰⁶ Another version of the VistA system will be sold as an open-source system by an IT services company called Medsphere Systems Corp. This version is called Open Vista and has been modified using open-source development methodologies to run in open-source systems.⁶⁰⁷

4.8.2.5 Fostering HIT Adoption Through Clinician Training Opportunities

A more direct effort to address the certainty factor is the effort by the California Health Care Foundation (CHCF) to increase clinician access to HIT education and training. Launched in December 2005, the CHCF is providing funding for nearly 50 California primary-care clinicians to enroll in two HIT courses—one providing a general overview of HIT, covering topics such as EHRs, consumer health, and telemedicine, and the other providing information about HIT certification. The HIT certification course provides physicians with information about how to implement and manage an EHR system, including EHR migration, legal and regulatory aspects, systems selection, implementation, and support.⁶⁰⁸

4.8.2.6 HIT Adoption Initiative

ONC awarded a \$1 million contract to the George Washington University and Massachusetts General Hospital/Harvard Institute for Health Policy to develop the HIT Adoption Initiative. This project aims to better characterize the state of EHR adoption and determine the effectiveness of policies aimed at accelerating the adoption of EHRs and interoperability. As part of the contract, the George Washington University and Massachusetts General Hospital/Harvard Institute for Health Policy will:

- ▶ Convene an expert consensus panel
- ▶ Conduct an environmental scan of measurements that assess the current state of EHR adoption and make publicly available the gaps in measurement data and known gaps in actual adoption

- ▶ Develop publicly available guidelines for EHR adoption measurement
- ▶ Design a set of EHR adoption surveys that use the guidelines to measure adoption in multiple settings of care across diverse populations
- ▶ Produce an annual report synthesizing the multiple EHR adoption measures to provide insight into the overall state of EHR adoption in the United States

A total of five annual reports will be produced by the HIT Adoption Initiative; the first will be published in the fall of 2006. The annual reports will track the progress of interoperable EHR adoption within 10 years—a goal set by the President.⁶⁰⁹

4.8.3 Standards-Focused Initiatives

Like the adoption of EMRs, standards adoption has been slow and inconsistent. There are a variety of standards-development organizations that may develop alternative standards for the same class of information. For example, the National Prescription Drug Programs developed a scripting standard that overlaps with the messaging standards defined by the HL7 standards-developing organization.⁶¹⁰ Physicians have expressed concern that new standards will make the products they purchase obsolete and increase practice overhead costs.

Efforts to push forward the adoption of standards are becoming more coordinated as the Federal Government works in collaboration with multiple stakeholders to identify existing standards or urge standards-setting organizations to create them. Physician organizations, particularly the AAFP, have also been involved in standards-setting efforts. In addition to standards that relate to medical terms and messaging structures, there are standards relevant to privacy and security and product certification that are also highly relevant.

4.8.3.1 Federal Health Architecture and Consolidated Health Informatics

The ONC was established in April 2004 by a presidential executive order. ONC reports directly to the Secretary of HHS and is tasked with developing and executing a strategic plan for national implementation of HIT across public and private sectors. ONC oversees a number of infrastructure development initiatives including the Federal Health Architecture (FHA) and the Consolidated Health Informatics (CHI) initiative.

The FHA was initiated in July 2003 to provide a framework for collaboration and interoperability across multiple federal health departments and agencies. The FHA has now evolved into a federal e-Government initiative directed by ONC and has partnerships with a number of federal agencies including the Office of Management and Budget, VA, DoD, Social Security Administration, and the State Department. The primary goals of the FHA are to improve coordination and collaboration on national HIT solutions and improve the efficiency, standardization, reliability, and availability of comprehensive health information solutions. As one of the original five lines of business supporting the President's Management Agenda, the FHA has established governance structures for the review and coordination of HIT initiatives across federal agencies and expanded its scope to encompass disease surveillance, EMRs, and

food safety. The FHA received \$2.8 million in funding for FY04 and requested \$3.9 million for FY05.^{611,612}

The CHI initiative has now been assimilated into the FHA. This initiative is charged with establishing federal health information interoperability standards (vocabulary and messaging) as the basis for electronic health data transfer in all activities and projects and among all federal agencies. CHI has already identified a portfolio of 24 target domains for data and messaging standards and adopted 20 uniform standards, resulting in 11 sets of standards to be used in federal information technology architectures.^{613,614,615}

4.8.3.2 The National Library of Medicine Clinical Vocabulary Support

The National Library of Medicine (NLM) provides development and support for some standard clinical vocabularies promulgated through the CHI initiative. The goal is to maintain these vocabularies for free use in the United States. In this vein, NLM has helped maintain and disseminate Logical Observations Identifier Names and Codes and licensed Systematized Nomenclature of Medicine Clinical Terms for national use. NLM has also addressed gaps in prescription drug terminology through the development of RxNORM. To ensure health information protection and privacy, NLM supported the uniform distribution and mapping of Health Insurance Portability and Accountability Act (HIPAA) code sets and other standards within the Unified Medical Language System. These efforts were supported with \$9 million in FY04, with another \$9 million requested in FY05.⁶¹⁶

4.8.3.3 Electronic Prescribing in the Medicare Program

In addition to the demonstration projects and pilot programs mandated by the MMA of 2003, the legislation also provided for the development of electronic prescribing standards for all prescriptions and other information related to beneficiaries obtaining Medicare-covered prescription drug benefits. The standards must allow for the secure transmission of the prescription, eligibility, and benefits information (including formulary and prior authorization requirements); information on the drug being prescribed; and medication list of the beneficiary (including information related to drug-to-drug interactions, dosage adjustments, etc.), as well as information on the availability of lower cost and therapeutically appropriate alternatives.⁶¹⁷

As published in the Final Rule of the Electronic Prescription Program, the HHS Secretary has adopted standards for electronic transmission of medical history, eligibility information, benefits, and prescriptions with respect to Medicare-covered Part D drugs. These include the National Prescription Drug Programs SCRIPT Standard and HL7 Messaging Standard.⁶¹⁸ As part of a one-year pilot project, all Medicare Prescription Drug Plan sponsors offering Medicare-covered prescription drugs to eligible beneficiaries beginning in January 2006 are required to establish and maintain an electronic prescription drug program that complies with the initial standards adopted in September 2005 by the Secretary.⁶¹⁹ According to the MMA of 2003, the final uniform standards for electronic prescribing must be adopted no later than April 1, 2008.⁶²⁰

4.8.3.4 Continuity of Care Record

The Continuity of Care Record (CCR) standards are essentially content standards for a minimum data set of the most important patient health information. Among the core elements included in the CCR standard are: identifying information (i.e., information about the referring clinician as well as to whom the patient is referred), patient identifying information and insurance information, health status of the patient (problems list, adverse reactions/alerts, current medications list, immunizations, vital signs, lab results, recent procedures, etc.), care documentation (i.e., some detail about the patient-physician encounter history), and care plan recommendation (free text entry section that may contain planned or scheduled tests, procedures, or treatment).⁶²¹ The CCR standards may be used as minimum content standards for core health information that must be captured by EMR systems or to create patient health records that are transportable and interoperable between provider EMR systems.⁶²² The CCR can be used to exchange patient health information in various clinical settings such as after a hospital discharge with a follow-up visit to the patient's primary-care physician, in an emergency setting, and for a referral to another physician. It can also be used to track auditing outcomes, guideline compliance, and quality of care.⁶²³

The CCR standards development was spearheaded by the AAFP in collaboration with a standards development organization, the American Society for Testing and Materials International. Other physician organizations have endorsed it and participated in its development, including the AMA, American Academy of Pediatrics, and Massachusetts Medical Society.⁶²⁴

4.8.3.5 Privacy and Security Solutions and the Health Information Security and Privacy Collaboration

In addition to the technical standards, efforts to standardize privacy and security solutions are also underway. HHS, through its ONC, recently awarded an \$11.5 million contract to the Health Information Security and Privacy Collaboration (HISPC). HISPC is a partnership consisting of the National Governors Association and other privacy, security, and standards experts. State privacy and security laws as well as organizational-level business policies vary significantly by locality. This variation in security and privacy practices poses significant challenges to interoperable health information exchange. The HISPC will work with state and local governments to assess their capabilities and develop plans that address the variation and challenges that accompany them.⁶²⁵

4.8.3.6 Certification Process and the Certification Commission for Health Information Technology

Complementary to standards development efforts is the standardization of the certification of EHR systems. Whereas computerized patient record systems have been under development for several decades by the VA and other federal offices, EMR systems are considered fairly new technologies by the general public. EMR products, as with any new technology, will continue to evolve and mature over time in both functionality and usability, creating uncertainty among physicians about the state of EMR technology. The larger, more stable vendors have focused on the hospital market. Because EMR vendors that focus on small physician practice settings are smaller and share a more fragmented market, they are less stable, increasing the risk of

investment for physicians.⁶²⁶ Physicians typically do not have the expertise to determine which EMR systems will comply with emerging national standards for connectivity, data storage and exchange, and privacy and security. Product certification of EMR systems may support vendor stability and product reliability, resulting in greater confidence among physicians to invest.

The Certification Commission for Health Information Technology was established in July 2004 to begin formalizing a certification process in a vendor-neutral setting. CCHIT is composed of the American Health Information Management Association, HIMSS, and the National Alliance for Health Information Technology. The initial scope of CCHIT was to certify EHR products for use in ambulatory care settings, including physician offices. Its broader goal is “to reduce the risk of information technology investment by healthcare providers, facilitate the offering information technology adoption incentives by payors and purchasers, and ensure interoperability of HIT products with emerging local and national information infrastructures.”⁶²⁷

All three organizations that compose CCHIT provided seed funding and staff. CCHIT received additional support from the California Health Care Foundation and recently received, from HHS through the ONC, a contract award totaling \$7.5 million over a three-year period. The ONC contract, called *Compliance Certification Process*, is considered as one of ONC’s major initiatives to further the widespread use of EHRs. As part of the contract, CCHIT submitted recommendations for ambulatory EHR certification criteria in March 2006 and certified its first round of ambulatory software vendors on July 18, 2006. The criteria put forth by CCHIT must include capabilities of EHRs that protect health information, standards for interoperability of patient health data, and clinical features that improve patient health outcomes.⁶²⁸

4.8.3.7 Standards and Interoperability Efforts by the American Health Information Community (AHIC) and the Health Information Technology Standards Panel (HITSP)

The American Health Information Community, known as the Community, was created in 2005 by the Secretary of HHS to provide input and recommendations on making electronic and interoperable health records, with consideration for privacy and security. The Community is charged with achieving these goals in a “smooth, market-led way.”⁶²⁹

In support of HHS and AHIC goals for interoperability, the Health Information Technology Standards Panel (HITSP) serves “as a cooperative partnership between the public and private sectors for the purpose of achieving a widely accepted and useful set of standards specifically to enable and support widespread interoperability among healthcare software applications, as they will interact in a local, regional and national health information network for the United States.”⁶³⁰ Funded by HHS and ONC, the HITSP was convened by the American National Standards Institute (ANSI) and a number of partners, including HIMSS, the Advanced Technology Institute (ATI) and Booz Allen Hamilton. HITSP is working to deliver interoperability specifications for the American Health Information Community breakthrough areas to “enable interoperability among different information systems, software applications and networks to communicate and exchange information in an accurate, effective, useful and consistent manner.”⁶³¹

5.0 Discussion of the Literature

5.1 Introduction

In the literature review chapter, we presented the evidence from studies in a number of domains, including:

- ▶ Impact of electronic medical records (EMR) and computerized physician order entry (CPOE) on quality, safety, effectiveness, and efficiency
- ▶ Costs, benefits, and net benefits/return on investment (ROI) of EMRs and CPOE
- ▶ Practice and physician characteristics that influence EMR adoption
- ▶ Perceived benefits and barriers of EMRs
- ▶ Theories of technology diffusion in general and EMR diffusion in particular

In this chapter we present a discussion of the literature related to the five domains listed above, identify key themes, and generate hypotheses regarding the factors influencing physician adoption of EMRs. The purpose of this chapter is to:

- ▶ Summarize and discuss significant findings from the literature review
- ▶ Identify from these findings factors for inclusion into a microeconomic framework
- ▶ Generate hypotheses that were subsequently explored in site visits

The rest of this chapter is organized as follows: In Chapter 5.2, we discuss the literature related to the impact of EMRs and CPOE on quality. In Chapter 5.3, we discuss the findings from the ROI literature. In Chapter 5.4, we analyze the practice and physician characteristics that have been identified in the survey literature as being relevant to EMR adoption. In Chapter 5.5, we analyze the models of EMR technology diffusion. Finally, in Chapter 5.6, we highlight the key themes that are relevant to a preliminary framework.

5.2 Discussion of EMRs and CPOE and Health Care Quality Improvement Literature

In Chapter 4.3 of the literature review, we presented evidence from studies that examined the impact of EMRs and CPOE on the following dimensions of health care quality: safety, effectiveness, and efficiency. In this section, we analyze the literature related to the same topics.

It is important to examine the link between EMRs and quality for a number of reasons. The survey literature shows that physicians expect to receive quality and safety benefits through the adoption of EHRs.^{632,633,634} Physician expectations of these quality and safety benefits may be influenced by the EMR safety and quality literature either through direct study or through the influence of peers who have knowledge of this body of research. The strength of the evidence, or the manner in which physicians perceive the evidence, may be a factor in influencing physicians' decisions to adopt EMRs in their own practices. The potential of EMRs to promote safety may resonate with physicians who place particularly high priority on the professional imperative to

“first do no harm.” This may be highly relevant to “innovators” who, according to Rogers, are more likely to embrace new ideas and may be characterized as believers.⁶³⁵ However, physician survey data continue to suggest that some physicians, especially those who work in smaller offices, feel the evidence for the benefit of EMRs is weak.⁶³⁶ A close examination of these studies seems to support these physician perspectives. One of the major themes that emerged from the review of the literature was the considerable ambiguity regarding the capacity of EMRs to promote safety, effectiveness, and efficiency in small practice settings. This lack of evidence creates uncertainty about the types of benefits that physicians expect to realize through EMR adoption.

Discussion of the Impact of EMRs and CPOE on Safety

Our review of the literature shows that the evidence linking the prevention of errors and adverse drug events (ADEs) with the use of CPOE is mixed and is highly dependent on the functionality and usability of the system. A strong positive impact of CPOE on ADE reduction was found, but primarily at premier institutions that are thought leaders in informatics. These include Harvard-Partners System, the University of Indiana–Regenstrief System, and the Intermountain Health Care System.^{637,638,639,640,641} Even within these institutions there is evidence that performance varies with level of functionality. However, there is also evidence that CPOE systems may contribute to errors, adverse events, and even mortality.^{642,643} These negative outcomes may be related to a variety of factors, including inadequate functionality, poor usability, insufficient training, or inadequate re-engineering of work processes. These factors were presented as key considerations in any CPOE implementation.⁶⁴⁴

In addition, the body of research related to the impact of EMRs on safety offers limited analysis of the capacity for office-based systems to reduce ADEs and mortality. The effectiveness of EMRs in the office-based environment requires extrapolation from the hospital environment; for “innovator” or “early adopter” physicians who may be highly motivated to address the well-documented prevalence of errors, this may be sufficient. However, the need to extrapolate the positive outcomes, and the recently emerging negative reports contribute to the uncertainty regarding the effectiveness of these systems in the outpatient environment. Uncertainty regarding future benefits can slow technology diffusion. Conversely, interventions that address uncertainty by providing evidence of efficacy may be useful in promoting adoption.

Discussion of the Impact of EMRs and CPOE on Effectiveness

As with the safety literature, the evidence of the impact of EMRs and CPOE on the effectiveness of care is equivocal; it therefore creates uncertainty associated with the ability of EMRs to promote effectiveness. Physicians may be influenced by this literature in ways similar to those discussed in the safety literature. It has been hypothesized that health information technology (HIT), especially EMRs, can promote more effective care by guiding physicians, through decision support, to practice medicine in a more evidence-based manner. A close examination of this literature suggests that the impact of EMRs and CPOE with decision support may be influenced by a number of factors. First, the manner in which the messages are constructed and delivered may influence their “usability.” And second, the nature of the clinical problem may also influence their impact. Routine schedule-based reminders for items such as yearly Pap

smears and immunizations may compensate for physician forgetfulness or inefficient paper tracking and reminder systems. However, one might hypothesize that in settings in which physicians have a higher level of endogenous knowledge regarding a clinical problem (e.g., hypertension), clinical treatment guidelines and prompts may contribute less to physician performance. This may be especially true in circumstances in which the clinical problem is cognitively complex, such that simple prompts would provide little added benefit to clinical judgment. This may explain, in part, why Asch found that the Veterans Administration (VA) did not perform as well in providing acute care as it did in providing routine preventive care.⁶⁴⁵

As with error prevention, this literature offers mixed messages to office-based physicians contemplating the adoption of EMRs and/or CPOE. Although there is some evidence that EMRs can promote more effective care through evidence-based guidance, the literature is not unanimous. Although the existing evidence may be sufficient for some innovator and early adopter physicians, its equivocal nature may contribute to uncertainty regarding the quality-related benefits of the technology. Furthermore, as with error prevention, the financial benefits associated with evidence-based care are unlikely to accrue to the physician unless he or she works in a highly capitated environment.⁶⁴⁶

Discussion of the Impact of EMRS and CPOE on Provider Efficiency

The literature suggests that EMRs, CPOE, and e-prescribing systems have the potential to promote cost efficiency by reducing errors and their costly consequences, reducing redundant and unnecessary lab tests, and promoting more cost-effective use of medication. It has been suggested that EMRs may also be used to promote workflow efficiencies that save providers time, and contribute reducing labor associated costs.

There is significant uncertainty regarding the realization of efficiency benefits. First, the evidence for improving provider efficiency in the outpatient environment is sparse and equivocal. Second, the realization of efficiency benefits is dependent on a number of factors. Differences in efficiency may be related to the sophistication of EMRs with regard to functionality and usability. Efficiency may also vary with the nature of the implementation and the extent to which workflow and human process have been modified to maximize the benefit of these technologies. Though focused on the inpatient environment, the literature underscores the importance of properly integrating technology and human processes (e.g., workflow) to produce optimal results.

Once again, the literature offers mixed messages to physicians contemplating adoption. Even if EMRs do ultimately increase productivity after an initial post-implementation decline, it is clear that this is not a universal experience. There is a significant amount of uncertainty regarding which systems will promote efficiency and what kinds of changes must be made to maximize efficiency. Such uncertainty can inhibit the adoption of complex and costly technologies.

In addition, physician realization of certain benefits, such as reductions in redundant tests, generic substitution and cost savings from ADEs, is dependent on the physician's reimbursement mechanism. As with realization of financial benefits from providing evidence-based care, most of these benefits will not accrue to physicians unless they work in a highly capitated

environment.⁶⁴⁷ Otherwise these benefits are more likely to accrue to private payers and the employers who purchase insurance from them, and to government payers and the taxpayers who subsidize them.

There are a few major themes that emerge from an examination of the literature on EMRs and safety, effectiveness, and efficiency. First, there are very few studies focused on the ability of EMRs to improve safety, effectiveness, and efficiency in the ambulatory environment. Second, the evidence regarding the impact of EMRs on safety, effectiveness, and efficiency is ambiguous, minimizing relevance to the small practice setting. Third, the ability of EMRs to generate these benefits depends on a number of factors, including levels of functionality, usability, and integration with workflow processes. In addition to the ambiguity associated with the ability of EMRs to generate these benefits, physicians' realization of benefits is also uncertain and depends on how the physicians are reimbursed. This dual uncertainty related to the generation and realization of benefits can significantly deter physician adoption of EMRs.

5.3 Discussion of EMR Cost-Benefit and ROI Literature

In addition to a review of the literature focused on EMRs and quality, we also examined the EMR cost-benefit and ROI literature. Although we found several limitations with this literature, it is important because it focuses on one of the most commonly cited adoption barriers for physicians who work in small groups: costs and a perception of insufficient net benefit.^{648,649} Aside from the actual quantification of costs and net benefits, the literature also provides useful categories of costs and benefits that may be relevant to an economic framework.

The cost-benefit literature varies in methods, rigor, and relevance to EMR adoption in the ambulatory environment. With the exception of the study by Miller, it is dominated by estimates based on projection models rather than systematic empiric measurement of the costs and benefits of actual implementations.⁶⁵⁰ We are unaware of any study that has, in a systematic fashion, prospectively measured the pre-implementation baseline and then assessed costs and benefits in the post-implementation state. Rather, the models tend to rely heavily on expert opinion and on citations from the benefits literature described in Chapter 4.3 of the literature review.

Furthermore, the researchers are often studying home-grown solutions, not commercial systems of the type that the average EMR consumer would be likely to purchase. One might also hypothesize that because these home-grown solutions have evolved slowly and incrementally over time, it may be difficult to capture all of the costs associated with their development, implementation, and change processes. In addition, the small cohort of authors who have conducted this research might be characterized as advocates for HIT. When cost-benefit estimates rely on expert opinion or judgment, "true believer bias" may produce excessively favorable results.

All of the nine ROI studies we reviewed described a strongly positive net benefit associated with EMR adoption. As noted earlier, only four of the nine ROI studies focused on the ambulatory environment. Of these, Wang and Miller focused on EMR adoption, and Johnston examined CPOE adoption in smaller practices. However, only Miller used empirical measurement of actual

costs and benefits to estimate ROI.⁶⁵¹ Costs at the individual practice level vary significantly in response to a variety of factors, including functionality, practice size, and negotiating capabilities, and the per-physician cost in these studies ranged between \$33,000 and \$43,000. The costs accounted for in the literature include one-time acquisition and implementation costs as well as ongoing annual costs. There are however, other kinds of costs associated with EMR adoption that have not been well accounted for in the literature. These include costs associated with researching and selecting a vendor, costs related to the customization and selection of the right sets of functionalities, and costs associated with technology obsolescence. All of these costs have been cited by physicians as being relevant to their EMR adoption decision.^{652,653,654, 655,656} For small practices, these costs can be significant and may constitute a significant burden, thereby deterring adoption.

Although Wang and Miller both described a positive ROI with EMR adoption in small offices, they arrived at this conclusion in different ways.^{657,658} Wang's model attributed the net benefit to reduced ADEs and redundant lab tests, and more cost-effective prescribing practices.⁶⁵⁹ This benefit was strongly associated with a capitated reimbursement environment. In contrast, Miller did not find that these factors contributed significantly to the net benefit in the 14 practices he studied. Rather, net benefit was driven by the reduced labor costs associated with lower transcription and file room costs, and increased revenue from better documentation and coding.

The cost-benefit literature does not include the potential benefit that may be realized due to the implementation of the Medicare prescription drug benefit. This new benefit provides seniors with drug coverage; however, that coverage will vary from plan to plan according to the drugs on each plan's formulary. In the future, it may prove very cumbersome for physicians to track each plan's formulary and prescribe medications in a manner consistent with formulary guidelines. Inappropriately prescribed drugs may require time-consuming interventions that may burden patients, office staff, physicians, and pharmacists. Prescribing systems that automatically track updated pharmacy formularies may yield significant benefit.⁶⁶⁰ However, this benefit remains speculative and unquantified.

Although the actual cost and benefit estimates in this body of research suffer from limitations, the consideration of costs and benefits remains central to the adoption decision. When benefits can be clearly demonstrated to exceed costs, adoption is more likely to be brisk. The calculations of these costs and benefits on the margin are extremely important to decision-making in microeconomic models of technology adoption. The net benefit or ROI literature is important because its positive findings are widely cited and may influence physician expectations regarding net benefit. However, despite the positive projections, Gans' survey suggests that many physicians feel the evidence is weak.⁶⁶¹ A critical assessment of this literature would support that perspective. Prospective studies of costs and benefits associated with EMR implementation would improve the evidence base considerably and may have a positive impact on physicians contemplating adoption.

5.4 Discussion of Literature on Practice and Physician Characteristics

In this section we discuss the findings in the literature associated with physician and practice characteristics that are correlated with adoption. This survey literature is fairly consistent in its findings with respect to specific variables that correlate with EMR adoption. For practice characteristics, these include size, ownership, location, and specialty. In addition, physician characteristics that have been shown to be relevant include age and specialty. A closer examination of this literature suggests that these physician and practice characteristics may serve as proxies for other variables such as economies of scale, time horizon for reaping benefits, learning effects, and others. In addition, several of these factors may heavily influence practice-specific costs and benefits, which in turn can influence adoption. In this section we discuss these practice and physician characteristics and develop hypotheses associated with them.

5.4.1 Practice Characteristics

Practice Size

The survey literature has shown that the rate of adoption varies significantly with practice size; larger practices are more likely to adopt than smaller practices. This is consistent with broader models of technology adoption in which larger firm size correlates with an increased propensity to adopt new technologies.⁶⁶² There may be a variety of reasons for this correlation; size may serve as a proxy for other variables that truly underlie adoption, including:

1. Ability to negotiate prices of costly technologies such as EMRs—Miller found that even within small practices, the ability to negotiate affected the price that small practices paid for EMRs. Because of their size, large practices may possess increased bargaining power and may be able to negotiate better prices.
2. Availability of resources to research the technology prior to adoption—As discussed in the literature review, practices cite lack of availability of resources to research EMRs as a barrier to adoption. Large practices may be able to overcome this barrier because they have significantly more resources in labor and capital to devote to vendor and functionality selection. These research tasks may be delegated to office staff or may be diffused over several physicians, thereby lowering the burden on any single physician.⁶⁶³ In addition, larger practices may be better able to absorb this cost because selection time may not be proportionate to the size of the practice. In other words, there are likely to be economies of scale here because smaller practices may have to do almost the same level of research as larger practices.
3. Ability to absorb risk and uncertainty— Because adoption of EMRs can lead to initial productivity losses, large practices may be better able to absorb shocks associated with the adoption of new technology.

These factors suggest that financial subsidies that lower the system cost, or reliable information that lowers the cost of information acquisition and vendor selection, may be helpful in stimulating adoption in smaller practices. In addition, practice size may also be a useful

parameter by which to design and prioritize interventions. For instance, interventions aimed at solo practitioners may be different than interventions aimed at practices of five to nine physicians. Alternatively, an economic model may suggest that it is most cost-effective to focus on a particular size cohort; say, two to four physicians.

Although practice size is strongly associated with adoption rates, like other rank effects, it is not an easily modifiable characteristic that can be altered by those seeking to influence adoption. However, as described above, size may serve as a proxy for a variety of other characteristics that may be modifiable, and which in fact may be more important than size in actually driving adoption.

Practice Ownership and Means of Compensation

As with practice size, practice ownership has been shown to be correlated with adoption. Practice ownership can be defined in a number of ways. One way is to categorize ownership as institutional versus noninstitutional or self-employed. Burt and Sisk classify ownership into the following categories: HMO, physician ownership, and “other.”⁶⁶⁴ Alternatively, Audet uses the classification of salaried and nonsalaried physicians, which would correlate to institutional affiliation. Regardless of the specific approaches to defining ownership, the literature shows a direct correlation between ownership/means of compensation and adoption rates. EHR adoption rates for physicians tend to be higher at the institutional level than among small physician offices.⁶⁶⁵

A variety of factors may drive the association of ownership and EMR adoption. One is the relationship between institutional ownership and larger practice size, which can confer advantages related to large size, as described above. Another is the financial structure of HMOs. These organizations are responsible for the total cost of care for a patient. Interventions that reduce adverse events and redundant tests and promote more cost-effective use of medications will yield financial benefits to the HMO. Physician-owned practices are less likely to realize these benefits unless they are reimbursed in a capitated fashion (i.e., provided a fixed reimbursement per patient). Those compensated in a fee-for-service environment are unlikely to realize a financial benefit from these quality improvements. Furthermore, in a physician-owned practice, the capital expenditure for an EMR will compete with the same revenue used to pay physician salaries. Gans and colleagues suggest that small practices could experience a 10 percent reduction in take-home pay as a result of EMR implementation, when factoring in the amortized initial costs and monthly maintenance fees.⁶⁶⁶

As Audet reported, salaried physicians used EMRs more than nonsalaried physicians.⁶⁶⁷ Institutionally owned practices are more likely to compensate physicians through a salary structure and are likely to be larger than physician-owned practices. Nonsalaried physicians’ income is more directly related to personal productivity; time devoted to nonpatient care activities, such as selecting and implementing an EMR, will have a direct impact on physician income.^{668,669} Smaller practices may have higher opportunity costs, which can hinder adoption.

Specialty

The survey literature has uncovered evidence that shows a correlation between specialty and adoption. As with ownership, practice specialty has been defined in different ways in the literature. Audet uses broad classifications such as specialist versus primary practices, while Burt and Sisk use very specific specialties such as orthopedic surgeons, cardiologists, and otolaryngologists.^{670,671} These authors find positive correlation between specialists and adoption.

As with size and ownership, specialty can serve as a surrogate for other variables. Different specialties have different information needs, and this distinction may influence the technology required to support those needs. For instance, psychiatrists have less need to regularly access lab or x-ray results, and their notes are more likely to be in narrative form and less conducive to structured and semistructured formats. In such cases, the disadvantages of “paper-based technologies” may not outweigh the costs associated with adopting newer technologies.

Template-driven documentation has also shown to be cumbersome for some and is often cited as a barrier to adoption for certain types of physicians.⁶⁷² Procedural specialties in which there are a limited number of routinized procedures are more compatible with template-driven formats that simplify electronic data entry. It is notable that, among proceduralists, ophthalmologists have relatively low rates of EMR adoption. This low rate may be related to the highly specialized nature of ophthalmologists’ information content, which often involves pictures and complex diagrams of visual fields.

In addition to functional needs, specialists, especially procedural ones, are reimbursed at a higher rate, thereby increasing the affordability of EMR to their practice.

Location

Location is another characteristic that has been correlated with adoption.⁶⁷³ As with practice size, ownership, and specialty, location is likely to represent a number of factors that drive differential rates of adoption. These include the presence of standards, the dominance of a single payor, and the existence of local health information networks.

Physicians have cited a lack of standards, both on a local and national level, as an obstacle to adoption.⁶⁷⁴ This contributes to uncertainty regarding the potential for obsolescence with existing commercial products. Standards may apply to messaging and vocabulary, system architecture, privacy and security, and other domains. Although local standards should harmonize with national standards, local variation is inevitable because national standards do not yet exist. Localities with more active participation in setting standards may have higher adoption rates, because standards can reduce uncertainty associated with technology obsolescence.

Health plans may glean significant benefit from broad physician adoption of EHRs.⁶⁷⁵ However, the role health plans play in providing support for adoption may vary by geography because the benefit realized by the plan will vary by market share. For example, if a region has a single dominant provider with more than 75 percent market share, it may be rational for that plan to subsidize physician adoption of EMR, CPOE, or similar technologies, because that plan is likely

to receive a dominant share of the benefit realized. Blue Cross Blue Shield of Massachusetts, which has dominant market share, plans to fund adoption and implementation of EMR, including training and change management, in 500 physician offices in three communities. However, if the market were fragmented, it would not be rational for a single plan to subsidize physician adoption because the benefit would be diluted across multiple firms, all competing with the funding firm. Further research may reveal parallel behaviors that can be mapped to geography and market share.

Although locality, like practice size, is not a modifiable attribute, understanding local needs and characteristics may help craft more effective programs to drive adoption. Inner-city and rural environments are likely to have unique needs, and geographies further removed from centers of leadership may benefit from local demonstration projects to “infect” the local culture and stimulate a contagion in the area. Environments with particularly low reimbursement rates may require more substantial financial subsidies. In areas with multiple health plans, incentives for payers to form coalitions to support local adoption may be fruitful to explore. An alternative strategy would be for policymakers to focus on a more limited set of regions that are further along in development to help them reach a “tipping point” that stimulates widespread adoption and interoperability. Demonstrable benefits in these densely connected communities could be the evidence necessary to spur more aggressive local investment in other communities.

5.4.2 Physician Characteristics

In addition to practice characteristics that influence adoption, the survey literature provides evidence on the impact of physician characteristics on EMR adoption. These factors include age, gender, and specialty. In this section we discuss the findings related to the impact of age and physician specialty on adoption.

Age

The survey literature is not unanimous in its findings related to age and adoption. Although Burt and Sisk found that physicians over 60 were less likely to adopt, Audet found no correlation with age.^{676,677} Burt and Sisk hypothesized that older physicians may be less comfortable with computers, making them less likely to adopt an EHR.⁶⁷⁸ Age, however, is likely to represent a broad range of personal characteristics that may influence adoption in different ways. How these sum to influence the decisions of a given individual may vary.⁶⁷⁹ Age is likely to correlate with income, with older physicians having higher income and net worth. These characteristics may encourage adoption. Finally, the correlation between age and adoption found in the survey literature may be explained by the length of the time horizon needed to realize benefits that may have varying effects on physicians of different ages. In the case of an EMR, a significant portion of the investment is a one-time sunk cost with benefits accruing over a longer period of time. The length of time needed to realize benefits is uncertain and may also depend on the level of functionality.⁶⁸⁰ Older physicians are likely to consider the cost of implementation and balance that against the time horizon over which they are likely to reap the benefits. An older physician close to retirement will therefore have a shorter time horizon over which benefits may be realized, making realization of benefits uncertain. This increased uncertainty may make older physicians less likely to adopt.⁶⁸¹

Specialty and Risk Appetite

Burt and Sisk found that the specialty of the physician, where specialty is very specifically defined, is correlated with adoption.⁶⁸² As with other practice and physician characteristics, specialty may be a proxy for other factors that may influence adoption. These factors could include associated individual characteristics such as risk appetite, comfort with uncertainty, attraction to new ideas, decisiveness, or comfort with technology. However, this area is not well explored in the literature, and we have found minimal evidence to lend credence to this hypothesis.

One might also theorize that individuals who choose specialties that are technology intensive and require more frequent adoption of new technologies, such as procedural specialties (e.g., surgery, cardiology), may be more adept at using new information technologies such as EMRs because of the cumulative learning effects that may be transferred. There is some support for this hypothesis in the literature. Kjerulff and colleagues have examined technology anxiety in different kinds of nursing units using the Technology Response Questionnaire.⁶⁸³ The authors found that nurses working on psychiatric units were most anxious about working with medical equipment, whereas surgical and intensive care unit nurses were least anxious. Those who were less comfortable with medical technologies were also less comfortable with computers.

Although one cannot draw any reliable conclusions from these observations, they do suggest that there are differences among physicians of differing specialties that may influence the proclivity to adopt new technologies in general and EMRs in particular. Similar to age and practice size, specialty is nonmodifiable. However, specialty may be a surrogate for other variables that may be relevant to the creation of the economic framework. These differences in specialty types may imply differences in the types of interventions and associated physician responses. For example, physicians may respond differently to similar technologies with different kinds of user interfaces.⁶⁸⁴ This may have implications for the manner in which adoption interventions are structured and communicated.

5.4.3 Discussion of Benefits and Barriers Literature

In addition to an examination of physician and practice characteristics that influence adoption, the survey literature and the Davies Awards provide data on the perceived benefits and barriers to EMR adoption.^{685,686,687,688,689,690,691,692,693,694,695,696} These perceptions provide insights into factors that deter or promote adoption. In the technology diffusion models from economics, the perceptions about benefits and barriers (which can be viewed as costs) are represented in the form of mathematical expectations. It is these expectations about costs and benefits that influence adoption in the models. It is reasonable to expect that physician perceptions are what affect adoption, even if the perceptions differ from reality.

The survey literature and the data from the Davies Awards provide information on the benefits that physicians expect to receive or have received from EHR adoption.^{697,698,699,700,701,702,703,704,705,706,707,708,709} The survey literature lists these benefits as important motivators of physician adoption. Expectations of specific types of benefits such as

improved charge capture, reduction in ADEs, decreased chart time, and improved employee retention from adopting an EHR have been cited in the literature (see Exhibit 31 in the literature review for a summary of expected benefits). A closer examination of these benefits reveals that they can be grouped into categories of expected benefits that lead to increases in revenue, decreases in costs, and/or improvements in quality and safety.

Physician surveys show that physicians expect to enhance their revenue through improved charge capture, improved collection rates, and decreases in denials.^{710,711,712,713,714,715,716,717,718,719,720,721,722}

Because one of the motivators for EMR adoption is the potential to increase revenue, thereby increasing income, we can posit that physicians consider income. This finding is consistent with economic models of physician behavior in which one of the variables that maximizes physician utility is income.⁷²³ The other avenue through which physician income can be increased is through a reduction in practice costs. The survey literature also found that physicians expect to reduce costs with the adoption of EMRs. These costs are associated with transcription, number of full-time equivalent employees, and other factors.^{724,725,726,727,728,729,730,731,732,733,734,735,736}

In addition to revenue enhancement, quality and safety improvement are important motivators of physician adoption. This has important implications for an economic framework of physician adoption because this set of motivators may be seen from both an economic and noneconomic perspective. Enhanced quality and safety may confer an economic benefit through a number of mechanisms. In highly capitated environments, a reduction in ADEs may result in lower total costs per patient.⁷³⁷ In a pay-for-performance program, compliance with quality indicators may yield enhanced reimbursement.

However, the professional imperative to “first do no harm” may also influence adoption. It would therefore be important to include non-financial motivators of adoption in an economic framework. Such beliefs are important motivators in the early adopter cohort described by Rogers.⁷³⁸ In microeconomic models, this may be captured in utility functions in which functions other than profit or income are maximized. These other functions may include variables such as patient safety.

There is significant convergence in the literature regarding the barriers to adoption in small physician offices. The strongest theme is excessive financial and time costs in the face of uncertain financial benefits. In many ways, other themes are derivative, in the sense that they either increase cost or uncertainty in some way. They include inadequate sources of reliable information regarding products and their costs and benefits; technical challenges, including poor usability and lack of support; inadequate infrastructure, including various types of standards; and inadequate support from colleagues.

Uncertainty regarding products may also be related to the notion of obsolescence. Although concerns over technical obsolescence were not specifically addressed, in two studies physicians cited a lack of standards as a barrier to adoption.^{739,740} It is plausible to infer that physicians fear adopting a technology which may not be compliant with future standards and which will be rendered obsolete when those standards are adopted. Uncertainty, or rather how a potential

adopter copes with uncertainty, is related to appetite for risk. Those who are more comfortable with risks are more likely to be early adopters.

Influence by colleagues, whether direct or indirect, has been shown to affect adoption rates, as suggested by Rogers.⁷⁴¹ The literature suggests that physician social networks are significant channels of information that may influence uncertainty, either positively or negatively, and thereby impact physician adoption behavior.

By better understanding the barriers to adoption, more effective interventions may be designed to accelerate adoption. Interventions can largely be divided into the following categories: financial subsidies; incentives or mechanisms to lower cost; information and training programs; infrastructure support, including technical and privacy standards; certification standards; and a more adoption-friendly legal environment. The success of any of these interventions lies in the details of how they are structured and implemented.

5.5 Discussion of Models Relating to EMR Technology Adoption

As stated in the literature review, there are very few articles from the peer-reviewed literature that focus on the diffusion of EMR in general, and on small practice settings in particular. In addition, all of the published articles in this area rely on aggregate industry-level models of diffusion in which social influence appears to be the sole driver of adoption. Most of these articles are based on the Bass technology diffusion model (discussed in Chapter 4.7 of the literature review) and therefore do not have the capability to capture decision making at the individual practice level nor the factors that influence these decisions – this approach does not provide any evidence into the actual behavior of physicians.⁷⁴²

Our review revealed three articles (Anderson and Jay, Ford, and Bower) on EMR diffusion that are based on the Bass theory of diffusion.^{743,744,745} Of these three articles, Anderson and Jay focus on use rather than adoption of EHR in an inpatient setting and is therefore less relevant to our study. Bower's model is focused on physician adoption, although the model encompasses practices of varying sizes. The recent article by Ford is the only one in a peer-reviewed publication that is focused solely on the examination of EMR diffusion in physician small practice settings.⁷⁴⁶ Regardless of the focus on type or size of care setting, all three articles rely on two parameters to explain diffusion: p , which represents the intrinsic tendency to adopt, and q , which represents the coefficient of imitation or social contagion. Variations in these two parameters generate alternative industry-level diffusion curves for EMR.

We identified four significant limitations with the Bass approach to modeling technology diffusion that naturally extend to existing models of EMR adoption that use the Bass approach.

First, it is unclear whose intrinsic tendency p captures, because physicians' intrinsic tendencies may vary. Intrinsic tendencies to adopt EMRs, for example, could be a reflection of individual tastes and preferences for risk or individual capabilities to learn new technologies. These articles do not describe how these varying tendencies can be aggregated into a single parameter p . One can, however, make certain assumptions that generate the single parameter p : 1) intrinsic

tendencies for all small practices are identical, which may not necessarily be the case, or 2) intrinsic tendencies vary and are somehow aggregated across all practices using a weighting scheme, which may lead to inconsistencies because alternative weights can change the aggregate representation of these intrinsic tendencies.

Second, these models rely on social contagion or imitation to explain adoption. Adoption in these models occurs as a result of epidemic effects, in which q captures the probability of adoption increasing with the number of adopters. Epidemic models have greater applicability in explaining the spread of infectious disease because the probability of getting infected is not typically chosen by the individual but is driven more by the probability of coming into contact with an infected person.

In contrast, EMR adoption is a result of a conscious decision undertaken by an individual physician or a practice. The decision to adopt is therefore likely to be influenced by multiple factors that drive adoption (as evidenced by the survey literature^{747,748,749,750,751}) rather than simply being a function of the number of adopters. In addition, the number of adopters may be relevant not because of a contagion effect but due to the following reasons: 1) an increase in the number of EMR adopters may increase the benefits of adoption through interoperability and 2) an increase in the number of adopters leads to an increase in the amount of more robust information on EMRs available to nonadopters. These models of EMR adoption do not explicitly account for these underlying reasons for diffusion to increase with the number of adopters. The Bass-based models of EMR adoption do not possess the appropriate structure to explore these factors underlying the relationship between contagion and adoption.

Third, predictions of adoption rates generated using the Bass approach are more akin to simple curve-fitting techniques in which values of p and q are chosen to fit a curve to a limited number of data points on EMR adoption.^{752,753} These curve-fitting methods do not provide insights into the underlying behavioral factors that drive adoption.

Fourth, because these models are based on specifications of aggregate industry adoption curves that have not been derived from individual adoption decisions, their construct does not allow one to account for a number of factors and the complex interrelationships that have been shown to be relevant to adoption in the literature. In developing a meaningful framework for EMR adoption, we believe it is important to use an approach that can incorporate the various factors identified in the survey literature as being relevant to adoption.

5.6 Discussion

Our review of the literature has revealed certain key findings that we believe are relevant to the development of the economic framework. In this section we briefly discuss four critical themes: costs, benefits, uncertainty, and the role of information. In Chapter 8.0 we present a detailed mapping of the evidence from the literature and site visits to the elements of the microeconomic framework.

Important physician motivators of adoption are costs and benefits (financial and nonfinancial in nature) associated with EMRs

The survey literature underscores the importance of costs and benefits in EMR adoption. Different types of costs have been shown to be relevant to the adoption decision, including acquisition and implementation costs. There are other kinds of costs associated with EMR adoption that have not been accounted for in the literature. These include costs associated with researching and selecting a vendor, costs related to the customization and selection of the right sets of functionalities, and costs associated with technology obsolescence. All of these costs have been cited by physicians as being relevant to their EMR adoption decision.^{754,755,756,757,758}

Similarly, there are a wide variety of benefits that adoption of EMRs could yield. These include both clinical and nonclinical benefits. From the literature it appears that physicians are motivated by both types of benefits. An economic framework for EMR adoption must account for physicians' preferences for increasing income and improving quality.

Factors such as physician and practice characteristics appear to indirectly affect calculations of costs and benefits

Although a number of practice and physician characteristics have been shown to be relevant, many of the factors can be linked to costs and benefits and the ability of a practice to realize them. In Chapter 5.4, we presented several factors that underlie the correlation between practice and physician characteristics and adoption. Most of these factors were based on considerations of costs and benefits or factors that influence them. These include economies of scale, learning effects, reduction in costs of selection and implementation through standards development, and reimbursement mechanisms that affect the ability of a practice to realize benefits. Some of these influences on costs and benefits would be relevant to the economic framework.

Physicians face considerable uncertainty in the realization of costs and benefits, which can act as a significant deterrent to adoption

One of the major themes that emerged from our survey of the literature is the uncertainty associated with costs and benefits. As stated previously, physicians cite excessive costs in the face of uncertain benefits as a barrier to adoption. In addition, physicians made specific observations about certain factors, including lack of standards and vendor instability that underscore this uncertainty. Physicians also perceive that existing evidence on costs and benefits is weak; this contributes further to the uncertainty associated with the value of EMRs. It would therefore be important to include uncertainty in an economic framework of EMR adoption. Models of technology diffusion in economics have traditionally emphasized the role that uncertainty plays in investment decisions; this factor can therefore be useful in guiding the development of the framework.

Role of information

Finally, given the uncertainty physicians face in adopting EMRs, information can play a critical role in lowering the uncertainty associated with costs and benefits. Technology diffusion models from the economics literature incorporate the role of information using a Bayesian specification. As stated previously, physicians may obtain information through a variety of sources. One source is through peer-reviewed literature; however, as discussed in Chapter 5.2, this literature is

ambiguous and may not help lower uncertainty. Another source is peer networks, the importance of which is emphasized in social network theories. Although economic models stress the role of information, they do not specify the channels through which the information can be obtained. One approach would be to integrate social network theory and models from economics to explicitly include peer networks. Regardless of how information is acquired, it would be important to include “information updating” in the microeconomic framework.

As previously stated, existing models of EMR diffusion do not explicitly account for these factors, which have emerged as being relevant to the adoption decision. The emphasis of these models has been on contagion effects and aggregate adoption curves. Contagion or the effect of peer networks is relevant because these networks can serve as channels through which information is obtained, however other factors must be considered as well. It is clear that any microeconomic framework of adoption must be based on individual- or practice-level adoption behavior, including considerations of costs and benefits and the associated uncertainties, and the role of information in altering uncertainty. The features that must be represented in the economic framework lend themselves to the use of options models of investment in economics that have been applied to technology diffusion.

6.0 Site Visit Summary

6.1 Introduction

In Section 5.6 we discussed key factors from the literature that have shown to be relevant for EMR adoption. These key factors of costs, benefits, and uncertainty formed the basis for our preliminary microeconomic framework for EMR adoption. Furthermore, our framework postulated that these costs and benefits were dependent on a number of the practice and physician characteristics that have been shown to be correlated with adoption. To validate the elements of our framework and to further explore certain hypotheses generated, we conducted telephone interviews and in-person visits with physician practices. In this chapter, we describe the findings from these eight interviews/visits. Despite the small sample size, the site visits provided valuable insights into factors that influence physician adoption of EMRs.

6.2 Approach and Rationale for Site Selection

6.2.1 Site Selection

We developed a list of sites based on recommendations from the TEP and referrals from Booz Allen subject matter experts. Although our goal was to include a spectrum of practice characteristics, diversity was limited by small sample size. We developed a set of criteria to evaluate potential sites for inclusion. These criteria and the associated rationale are presented in Exhibit 34.

Exhibit 34. Rationale for Site Selection Criteria

<i>Criterion</i>	<i>Rationale, Comments, and Goals</i>
Practice Size 1-9 Physicians	<ul style="list-style-type: none"> •Accounts for approximately 80% of physician owned offices with about 60% being 1 to 4 physicians (<i>AMA survey; Casalino; Burt</i>) •In surveys, 10 physicians and over are often bucketed in cohorts that include 20 to 50 physicians – relatively large practices (<i>AMA, Burt, Gans, Audet, others</i>) •Increased size highly correlated with adoption; significant increase in adoption in the cohort of 10 MD and up. 1-9 captures the least likely to adopt (<i>Burt, Audet</i>) •Goal: include diversity of practice sizes from 1 to 9 physicians, with emphasis on 5 and less
Physician ownership of practice	<ul style="list-style-type: none"> •Physician ownership is strongly correlated with lower adoption rates (<i>Burt and Sisk</i>) •Goal: only include physician owned practices
Practice Specialty	<ul style="list-style-type: none"> •Certain specialties, especially procedurally oriented specialties appear to be correlated with increased adoption (<i>Burt</i>) •Exceptions may include ophthalmology, gastro., (<i>Gans</i>) •Goal: include a diversity of specialties
Practice Location	<ul style="list-style-type: none"> •Location may influence adoption because of reimbursement rates, HMO penetration, local culture and social networks etc •Goal: include a diversity of locations
Age range of MD	<ul style="list-style-type: none"> •Correlation with age over 60 and lower rates of adoption (<i>Burt</i>) •Goal: Include a diversity of practices that capture a spectrum of physician ages
MD Gender	<ul style="list-style-type: none"> • No correlation with adoption in current literature, but balance in informant cohort is desirable
Years since adopted	<ul style="list-style-type: none"> • Recent implementations may be more reflective of rapidly evolving environment, however some members of the TEP felt older implementations would also provide insight. With older implementations we may get a better perspective on costs and benefits • Goal: Emphasize more recent implementations (within 2 years) but also include smaller number of older implementations (3-6 years)
Adoption Status	<p>Implemented Adoption</p> <ul style="list-style-type: none"> • Can provide perspective on selection and implementation process • Goal: Select 4-5 offices that have already adopted (per TEP discussion) <p>Considering EHR Adoption</p> <ul style="list-style-type: none"> • Can provide insight into current process of deliberation • More challenging to identify; more limited choice of offices • Goal: Select 1-2 offices that are considering EHR adoption (per TEP) <p>Decided Against Adoption</p> <ul style="list-style-type: none"> • Can provide insight into the perspective of the non-adopter • Challenging to identify; more limited choice • Goal: Select 1-2 offices that have decided not to adopt (per TEP)
Willingness to participate	<ul style="list-style-type: none"> • Those more willing to participate are more likely to cooperate with extensive interview process (3+ hrs phone; 3+ hrs in person) • Goal: favor offices that appear more willing to participate
Other	<ul style="list-style-type: none"> • Other unique attributes or relationships that may be identified. For example, offices where paper and electronic health records are used concurrently.

A practice profile screening tool was developed to gather information on practice demographics including size, status of EMR adoption, age range of office staff, and location. Practice sites were contacted via phone to gather the profile data and to determine willingness to participate in a site visit. This information was used to narrow the list of sites to those that matched the pre-determined criteria. Thirty-four sites were contacted by phone. Of those, 21 sites completed a

preliminary questionnaire. Of these 21 sites, 19 agreed to participate further in phone interviews/site visits; however none were in the categories of “Considered and Not Adopted” or “Never Considered Adoption.” Based on the established criteria, the eight sites shown in Exhibit 35 were selected.

Exhibit 35. Selected Sites

Site ID	Site Specialty	Number of Physicians	Practice Location	Geographic Description	Implementation Status	Participation Level
Site A	Family Medicine	4	Murfreesboro, TN	Urban (medium)	Adopted – 5 yrs.	Phone and Site Visit
Site B	Ophthalmology	2	Indianapolis, IN	Urban (large)	Adopted – 3 yrs.	Phone and Site Visit
Site C	Cardiology	2	Sheboygan, WI	Suburban	Adopted – 2 yrs.	Phone and Site Visit
Site D	Internal Medicine and Pediatrics	6	Laurel, MD	Suburban	Adopted – 2 yrs.	Phone and Site Visit
Site E	Pediatrics	3	Bridgeport, CT	Urban (medium)	Adopted – 7 yrs.	Phone and Site Visit
Site F	Ob/Gyn	1	Jesup, GA	Rural	Adopted – 3 yrs.	Phone Only
Site G	Family Medicine	5	Wilmington, DE	Urban (medium)	Considering – Signed Contract	Phone Only
Site H	Pediatrics	1	Chicago, IL	Urban (large)	Considering – Signed Contract	Phone Only

The sites were not compensated for their participation. We appreciate the generous contribution of their time and the candor with which information was provided.

6.2.2 Site Visit Methodology

Based on comments received from the TEP and ASPE, we developed structured guides to facilitate discussions with the sites. To ensure effective data collection and to minimize burden on the sites, the discussions were conducted in two phases—telephone interviews, followed by site visits. To reduce burden on the sites, we limited the number of practice staff who participated in the interviews. In most cases, a single point of contact, either the physician who championed the EMR adoption effort or the office manager, served as interviewee.

Telephone Interview

We developed a telephone interview guide (Appendix B: Phone Interview Instrument) for use in the phone interviews. The original intent of the guide was to facilitate a detailed interview process involving multiple staff members. To increase participation by physician practices, we modified our approach to permit completion of the telephone interview in 1 hour.

Site Visit Interview

Upon completion of the telephone interviews, we selected a subset of five sites for in-person visits. All five sites had adopted EMR systems and were willing to participate in the in-person visits. A two-person team visited each site and conducted 3-hour interviews. The team met the

practice staff but focused on interacting with the physician or office manager most responsible for the EMR purchase and implementation. All the sites provided a demonstration of their EMR system and related functionality. The site visit discussions were guided by the In-Person Site Visit Instrument (Appendix C: In-Person Site Visit Instrument). Following the completion of site visits, we analyzed the data to identify emerging themes such as types of functionality adopted, barriers to adoption, and others.

The telephone and site visit discussions focused on six major categories:

- ▶ **Practice Demographics.** To further characterize a given practice, we gathered information on practice demographics.
 - Practice age and specialty
 - Number of locations
 - Total number and mix of full-time and part-time staff (clinical and nonclinical) in practice
 - Age and tenure of physician(s)
 - Practice ownership structure

- ▶ **Billing and Income.** To the extent practices were willing to provide information, the sites' billing and income information was collected.
 - Average income of physicians in practice in 2005
 - Total gross revenue in 2005
 - Total costs in 2005
 - Major types of costs
 - Labor costs (distribution of labor costs—clinical versus administrative)
 - Non-labor (e.g., office space, computers, hardware, software, other overhead) costs
 - Reimbursement methods (Medicare, Medicaid, private insurance, self-pay)
 - Number of patient encounters per physician per day
 - Physician hours at practice—full-time/part-time
 - Size of patient population

- ▶ **EMR Decision-Making Process.** The goal of these discussions was to understand the complexity and resource intensity of the selection process. As stated in Chapter 5.0, the costs associated with this process are under-reported in the literature.
 - Prior experience with EMRs and other technology (including practice management)
 - Reasons for investigating EMRs
 - Description of process to research and evaluate an EMR, including:
 - Selection of vendors for evaluation
 - Ease of evaluation
 - Resources expended in research and selection including:
 - Timeframe for evaluation
 - Receipt of monetary and non-monetary resources for EMR selection

- Decision-making process
- Challenges in evaluation of an EMR

- ▶ **EMR System Characteristics.** The focus of this section was on the EMR system characteristics, EMR costs, and implementation. The EMR functions, usability, and customizability of the EMRs purchased were also addressed. Sites were asked to describe their implementation processes and any challenges encountered in their processes.
 - Vendor
 - Description of functionality
 - EMR costs
 - Implementation process
 - Financing of purchase

- ▶ **Actual and Perceived Benefits.** In this section we asked sites about the actual or perceived benefits of EMR adoption. We explored both the financial and nonfinancial benefits.
 - Improved patient safety
 - Improved quality of care (decision support; evidence-based medicine)
 - Cost reduction (labor/other)
 - Improvements in workflow processes
 - Revenue enhancement/charge capture
 - Differentiation in marketplace (have competitors adopted/not adopted; have patients requested)
 - Improvements in your quality of life—increased leisure time
 - Other

- ▶ **Barriers to Adoption.** The literature review revealed a number of barriers. Cost has been identified as a significant barrier,⁷⁵⁹ but the literature did not explicitly address cost-related factors such as access to credit and their relative importance. Other barriers such as uncertainty regarding obsolescence and the uncertainties created by an inherently complex technology were hypothesized but not specifically explored.⁷⁶⁰ Some of these factors are explored in greater detail in the telephone interviews.

- ▶ **Post-Implementation Observations.** Adopters were asked to reflect on their current use of EMRs and articulate lessons learned that might benefit those considering adoption.

6.2.3 Project Limitations

Any interpretation or use of the information presented in this report must take into consideration the inherent limitations of this project. The results of this investigation are limited by the sample size of eight sites, which cannot reasonably be considered a representative sample of small physician practices. Nonetheless, the results do provide information that offers insight about the experiences some small physician practices have had with implementing and using EMRs. A further limitation of this investigation is that information gathered is not consistent from site to site. The ability to collect comprehensive data consistently across sites was constrained by the availability of sites for phone interviews and site visits.

6.3 Analysis of Site Visit Data

We analyzed the data gathered from the telephone interviews and the in-person visits to identify key themes. We present these key themes in this section, followed by a brief discussion of findings for each site.

6.3.1 Practice Demographics, Income and Background

Each of the eight sites included in this study were physician-owned and -operated practices, with fewer than nine physicians per practice. The practices represented a diverse set of sizes (staff to physician ratios for the sites, in order of presentation, were: 11:4, 3:2, 24:2, 11:5, 18:3, 10+:1, NA:5, 2:1), ownership structures, and specialties (including family medicine, pediatrics, cardiology, and ophthalmology). The physicians included in the study also represented a diverse mix of ages and sexes. Physician ages ranged from 30 to 74 years. Two sites each had one physician who was significantly older than the other physicians. One of the sites trained a previously retired physician (over 70 years old) to adopt the EMR system soon to be implemented in the office. The other site, which is made up of a father and son team, allows the older physician to retain his paper records as he is unwilling to use the EMR. Specialists commented that EMRs purchased required customization to meet the particular needs of their practices. The sites represented a wide range of income levels, though most of the physicians' incomes were in the \$100,000–\$200,000 range.

6.3.2 EMR Research and Decision-Making

There were several factors that motivated EMR adoption in these practices. These included the need to improve efficiency, reduce storage requirements, share medical records between multiple office locations, and eliminate loss of charts. Some physicians explained that they were drawn to EMRs as “the thing to do” or by a general interest in HIT. In each case, physicians recognized the importance of HIT as the “wave of the future” and anticipated an increase in EMR adoption rates.

All the practices except one evaluated multiple EMRs prior to selection. Practices relied on a variety of sources to gather information about EMRs: examining the literature, attending conferences or trade shows, consulting their respective specialty societies, speaking with peers and colleagues, and experiencing EMR demonstrations both online and in person. Each practice initially considered multiple vendors (between 1 and 25) and then conducted detailed evaluations of approximately three to four EMR vendors.

In sites with multiple physicians, the EMR effort was led by a physician champion who was able to achieve unanimous buy-in from all the physicians in the practices. Only some physicians however were interested in gaining the perspectives and buy-in of all staff members who would use the EMR systems that were considered. In our small set of sites, this factor did not seem to make a difference to sites in terms of their ability to successfully implement and train all staff to the system. In all cases, sites reported that all staff were very satisfied with the system post-implementation, including staff members who were initially hesitant.

In all the practices, the EMR adoption effort, from initial research to implementation, was championed by a single committed member of the practice's senior leadership. In most cases this champion was a physician, and in all cases but one, that physician had prior experience with EMRs. In some cases that prior experience included extensive IT knowledge, such as a background in electrical engineering. This existing human capital appears to provide a significant advantage to practices in overcoming the barriers to adoption. The one physician interviewed who had no prior first-hand experience with EMRs found the research and decision-making process to be overwhelming and sought the support of a consultant in his implementation.

6.3.3 EMR System Characteristics

Three of the five visited sites demonstrated EMRs with very similar user interfaces that resembled a series of folders, allowing users to access aspects of a patient's chart and administrative tasks as one would navigate a desktop. One of the sites used a product that had similar functionalities as the others, but presented the user with a single screen that walked one through workflows. Another practice had a very different user interface that used long lists of text options that were manipulated by the user to input information from patient interactions. In all cases, offices with EMRs had practice management systems, but only some were fully integrated with the EMRs. All of the systems discussed with the sites had basic functionalities of scheduling, reminders, messaging, and medical history. Some systems had enhancements such as order entry and electronic prescribing (e-prescribing.), as well as alerts and reminders. All practices visited used a mix of desktop personal computers (PCs) and laptops or tablets.

Practices spent between \$15K and \$80K on the purchase of software which may (or may not) have included a practice management system. In all cases, onsite training and implementation were included in the purchase price of the system. Costs for continuing maintenance and support varied by practice. Site expenditures on hardware varied because some sites had implemented other HIT systems prior to EMR adoption, while others had to update their entire IT infrastructures to accommodate the EMR.

Exhibit 36. Site EMR Purchase Expenditures

Costs of Purchase and Implementation	Site A	Site B	Site C	Site D	Site E	Site F	Site G	Site H
Hardware	\$54K	Not cited	Total – \$125K	Not cited	(see total)	\$42K	(see total)	\$15K–\$20K
Software	\$46K (includes practice mgt.) + 15% as licensing fee	EMR – \$30K (\$7,500 licensing fee included)	\$80K (includes practice mgt.)	\$57K	Total \$150K (includes hardware)	EMR – \$20K, PMS – \$12K	(see total)	\$15K–\$20K
Software training and installation	Included in price	Included in price	Included in price	Included in price	Included in price	Included in price	\$100K in total up-front costs	Not cited
Software maintenance and support	15% of software purchase price	\$1,400/yr	\$417/mo for software and \$667/yr for interface support from vendor (total maintenance including external IT contractor = \$30K/yr)	\$1,500/qtr (maintenance fee includes vendor support)	Not cited	\$6K/yr for both EMR and PMS	\$1,500 or less per month (20% of up-front total per year in maintenance)	Not cited

6.3.4 Actual and Perceived Benefits

The five practices that adopted and implemented EMRs identified many of the benefits of adoption that are cited in the literature. While none of the sites quantified all benefits they claim to have realized, most were able to offer anecdotal or qualitative evidence to justify their perceptions of benefits.

Impact on Efficiency

- ▶ All the practices that have implemented EMRs cited improved efficiency as a general benefit to adoption.
- ▶ Some cited employee satisfaction/physician quality of life improvements.

Impact on Revenues and Costs

- ▶ Some of the sites were able to quantify personnel and other cost savings and chartroom storage savings.
- ▶ All that have implemented EMRs cited improved charge capture as a benefit of adoption, but only two demonstrated an increase in coding and billing rates/collections as a result of the EMR.
- ▶ Several noted that the improved ability to document through an EMR allows them to properly code and bill for services without the fear of audits from insurance companies; the EMR gives the physicians the confidence to code properly.
- ▶ Some noted a discount on malpractice insurance rates as a result of adoption.

- ▶ Some described the EMR as a means of differentiating their practice in the marketplace.

Impact on Quality

- ▶ While all sites felt that the EMR enhanced their decision-making abilities, they attributed this to the availability of data on patients through the system.
- ▶ None cited a reduction in medical errors or the ability to rely on the system for any decision support.
- ▶ Practices did cite enhanced quality of patient care.

6.3.5 Barriers to Adoption

The process for researching and evaluating EMRs has been cited in the literature as a potential barrier to adoption owing to the perceived and experienced difficulty of this process by physicians. The physicians interviewed in this study, with the exception of one site, did not face these barriers. The majority of the sites did not believe the research and decision-making process to be a barrier to adoption; however, several did note that unanimous buy-in and commitment to the process is needed for success. Many sites further cautioned that having reasonable expectations for adoption of EMRs is a critical success factor. Price of EMR systems was not a barrier or deterrent to any of the sites, nor was the actual implementation process. While some of the sites noted implementation challenges such as system “bugs,” all of the sites were able to implement EMRs successfully by relying on vendors, trainers, or IT consultants to assist with challenges that could not be overcome internally. The sites that had implemented were generally able to reach a steady state of operations after 3 to 6 months of implementation.

It should be noted that some of the sites included in this evaluation were “beta” sites, that is, they serve as test sites for the vendors. This distinction offers the sites special privileges with their vendors such as discounted or free enhancements to their EMRs. This also suggests that these sites represent highly successful implementations and may not be representative of the broader implementation experience. This may explain, in part, the absence of reported barriers to implementation. The prior experience of physician champions may have also played a role in achieving a smooth implementation.

6.3.6 Post-Implementation Observations

The products purchased by these sites varied substantially in their functionalities and appearances, yet all were enabling practices to improve care. Successful practices have viewed implementation plans as a critical step. Strong leadership, sound planning, and prospective understanding and acceptance of the challenges are essential. Currently the purchase of one EMR system is an irreversible investment because it is impossible to migrate from one system to another. One physician noted that this “proprietary prison” may be preventing many practices from purchasing and that more universal standards may help address this problem.

6.4 Site Visit Findings

This section provides detailed information collected from sites. Some sites had extensive experience with EMRs before considering adoption; others did not. Information is presented

below in narrative form and represents information from both interviews and site visits. This reflects input not only from sites that are considering adoption but also from sites that have adopted EMRs.

Sites were asked to provide billing and income information. Some sites provided very accurate and detailed data; some provided approximations; and others elected to not provide this data. The billing and income information is provided to depict a rough estimate of the practices' financial characteristics. None of the practices received any monetary assistance for evaluation, purchase, or implementation of EMRs.

6.4.1 Site A

6.4.1.1 Practice Demographics, Staffing and Background

Site A is a family medicine practice in Murfreesboro, Tennessee, with two locations. The practice was formed in 2000 by the four physicians who were formerly employed by a hospital. The offices are staffed by:

- ▶ Four physicians (MDs)—one of whom is part-time
- ▶ One part-time nurse practitioner
- ▶ Three medical assistants
- ▶ Two LPNs
- ▶ One office manager
- ▶ Three receptionists
- ▶ One billing assistant

Two of the physicians are male and two are female. The physicians' ages range from 40 to 53. Two of the physicians have been in practice for 8 to 9 years; two have been in practice for 25 years. There are two MDs at each office site.

The practice currently communicates with patients via telephone and mailed letters.

6.4.1.2 Billing and Income

Site ID	MD Salary	Annual Gross Revenue	Annual Operating Expenses	Reimbursement Mix	Size of Patient Population	Practice Ownership Structure
Site A	\$165K – \$210K (range)	\$1.2M	\$702K	Medicare – 35% Private Ins. – 60% (all FFS)	~9,000	S Corp. (each MD is own profit center)

6.4.1.3 EMR Research and Decision-Making Process

The physician responsible for initiating the EMR adoption at this site describes her role at the practice as “head of IT.” She and one other physician had prior experience with EMRs, but the other two physicians in the practice did not. The practice began investigating EMRs in April 2000 and collectively selected a product in July of that year. The EMR implementation was completed by October 2000 and coincided with practice inception.

The physician champion was responsible for the research process and decision making. She researched the Internet, the family practice literature, and other sources. The physicians in the practice knew they wanted billing, scheduling, and EMR software in one system, which narrowed the field of products. At that time there were very few EMR products on the market—approximately 20 to 25. The practice focused on the “top-ranked” products according to the literature. One partner had prior experience with one of the products, which he ruled out. The practice examined three products through in-person and virtual demonstrations.

Each physician viewed a demonstration of at least two programs identified through the lead physician’s research. Two physicians went on site visits along with the office manager. In total, the practice may have spent 50–60 hours, spread across different staff members at different times, researching and selecting an EMR. The entire evaluation process took 6 weeks. The decision to select the EMR product was unanimous, and the product selected was one that two MDs had previously seen years ago when it was one of the first computerized records in the world—this confirmed for the group that they were “on the right track” with their selection. There were no skeptics in the group.

The evaluation process was straightforward for the practice, and early in the process it became clear that one of the products considered was more established and had better features than the others. The practice received adequate support from the vendors for the products they examined.

6.4.1.4 EMR System Characteristics

EMR system functionalities include disease tracking, medication and side effects information, drug interaction alerts, allergy checking, drug and disease checking, and a digital electrocardiogram (ECG/EKG) that is integrated with the program. All test results from the local hospital are electronic and automatically received and uploaded into patient charts. Faxes to the office are received as computer files that are attached to patient charts. The practice has a two-way interface for labs that allows the office to input orders and receive results. The EMR enables trending and reports of lab results over time. The EMR system included 150–200 templates that can be used to generate letters and perform other administrative tasks. The EMR system automatically creates and populates the letters, to include any test results. The EMR system has a secure web portal that allows patients to message the office, conduct online visits, ask questions, e-mail practitioners, schedule appointments, and request refills. The practice elected not to purchase specific functions such as automated formulary updates because the physicians did not see a benefit to these functions.

The total cost of the EMR acquisition was approximately \$100,000; the hardware and technical support cost was \$54,000 and the software cost \$46,000. The office paid an additional 15 percent of the original sales price for the annual licensing fee. The practice did not negotiate with the vendors on the acquisition or annual costs. Two of the partners took out loans and the other two paid their shares with out-of-pocket contributions. The software was sold to the office on a per-license basis. The office chose to buy 13 licenses to eliminate the overhead of managing limited access for staff. To reduce costs, the number of concurrent users can be limited.

As implementation began, a software trainer prepped the office staff by telephone once a week and then came to the office for 4 days to train staff and set up the system. Support was available to the office at all times via telephone and e-mail. The office was up to normal patient capacity in 1 week. After 1 month of implementation, the office was functioning relatively smoothly despite an ongoing technical “bug” that caused some EMR system problems. Two of the physicians gave up transcription completely after 1 day of EMR use, while the other two gave it up after 6 months. The office elected not to do any paper-to-electronic conversions and instead only input immunizations and problem list information into the electronic charts. They input all other patient information when patients presented at the office. To accomplish this, the office staff entered data from paper charts for the first 6 months of implementation. The office is very satisfied with the system and stated that the system templates can even support complicated records for patients with multiple comorbidities.

Comparing EMR to Paper Processes

The physician interviewed was asked to compare the EMR functionalities of the system to her previous experience with paper. Overall she found that the EMR documentation and medication ordering functionalities are far easier to use and more efficient than the paper processes for these functions. Although the EMR is far more efficient with respect to results viewing than the paper process, the basic alerts that are part of these functions are only “Good” compared to paper because the physician does consider these as major workflow enhancements. In the area of test ordering, the physician finds no difference between the EMR process and the paper process except for the EMR’s communications functions, which are a vast improvement over the paper function.

6.4.1.5 Actual and Perceived Benefits

Workflow Efficiency

The site has realized benefits in many areas of patient care and administrative management. The EMR has enabled many workflow efficiencies and automated processes that have qualitative and quantifiable benefits for the practice. The site can now download and send all labs electronically, which saves paper and increases efficiency. Diagnostic imaging can be attached to the charts online, and other results can be scanned in by computer-fax. Printing prescriptions has made prescribing a fast and easy process, and next year the practice hopes to implement an e-prescribing system. The MDs feel as if they have more leisure time due to overall organization.

Some points of note with respect to workflow efficiency cited by this practice include:

- ▶ The office has placed all paper charts in chart storage areas in the basement and attic because they are never touched.
- ▶ EMR allows this two-site practice to serve any patient at either location at any time.
- ▶ EMR altered the office’s workflows: receptionist sits at her desk; medical records staff has been reduced from two to one; nurses now draw blood and provide patient care instead of hunting charts; the office can use the Internet for patient communication; transcription has been eliminated.

- ▶ Patients can complete medical history by themselves in the office on a computer or can do it online from their homes.

Revenue Enhancement and Cost Savings

One office site was able to reduce its staff by 1.5 full-time equivalents (FTEs). One MD no longer needed his transcriber. The practice saw general efficiencies in administrative work that led to staff savings overall. The EMR has improved charge capture and coding by auto-coding and double-checking entries. This has saved the office time and effort; when used appropriately, the system forces MDs to double-check coding.

Quality

The system creates tables to trend lab results over time, which improves patient care. The office participates in a research project that gives it data on its performance compared to other participants in the national study of over 100 practices. Nationwide, the office is in the top 10 percent of practices in meeting compliance goals, a success that the physicians attribute to the EMR. Improvements in quality have also been demonstrated through this study; due to improved documentation, the average cholesterol level of the practice's patients has decreased.

Some of the key points cited by the practice related to quality benefits realized include:

- ▶ Information is not lost; charts are always available; and physicians feel that they are providing better care.
- ▶ Patients recognize the benefits of the EMR and appreciate the readable prescriptions, the fast generation of letters, and the Internet connectivity that allows them to communicate quickly with the office.
- ▶ EMR has won the office awards, and the staff take pride in these achievements.

6.4.1.6 Barriers to Adoption

Serving as a "beta" site for the vendor has given the practice the opportunity to interact with colleagues across the country who are interested in the EMR system. Many of these colleagues have subsequently adopted EMRs, although not without problems. As with any technology, there can be "glitches," and the practice has needed to anticipate this in order to make the system work. The physician champion explained that there are failed implementations, even with this system. She suggested that these failures may result, in part, from the unrealistic expectations held by many physicians. Further, many physicians are unprepared to use computers and do not understand how to customize the system or modify their office procedures to maximize benefits.

Although the EMR evaluation can be a complicated process, the physician champion stated that this practice did not consider this a barrier to adoption. She believes that consultants can be helpful to some practices but that a small practice does not need one if they can identify their needs and locate an attentive vendor.

The physician interviewed stated that in her practice there are some ongoing challenges. Some physicians fail to use the system to its fullest potential. For instance, one MD in the practice does not use the coding functionalities of the EMR to their fullest.

6.4.1.7 Post-Implementation Observations

Since implementation, the MD has found that carrying a laptop around the office is more useful than using a tablet PC. Tablet PCs not only are more expensive than laptops but their batteries typically die after 1.5 hours. The office does not use the EMR's handwriting recognition software because it does not work very well. For those patients who have routine or frequent appointments, the practice offers the option of conducting virtual physician visits through the secure web portal. The practice has found that using the EMR's coding functionalities is critical to realizing charge capture benefits. The partner in the practice with the highest revenues captures all of his charges through assiduous documentation. The physician interviewed finishes her notes in the room with the patient, while another physician waits until the end of the day. His charges are only two-thirds of hers, which she attributes to his pattern of use.

System maintenance has not been unreasonably demanding on the practice staff. The practice now does one upgrade per year, which is covered under its maintenance contract with the vendor. Most problems with the EMR system can be fixed by the vendor over the phone or through the Internet.

The physician interviewed participates in vendor-sponsored user meetings and gives lectures at national conventions on EMRs and their benefits. She emphasizes that sites considering adoption must thoroughly research EMR products before making a selection decision. Further, they must be committed to a thorough implementation effort. To get the greatest benefits from EMR, offices must make paperless operations a goal and should commit to finishing notes in the room with patients. Some other post-implementation observations include:

- ▶ Sites should assess the stability and quality of the support they will receive from the vendor because this is a critical success factor.
- ▶ When pricing out the costs of adoption, MDs should include the costs of database, maintenance, and upgrades and spread the costs over at least 5 years.
- ▶ Purchasers should recognize that many vendors offer variable rate maintenance fees that can increase over time.
- ▶ Purchases may need additional features to make full use of the product, but some of these features may not be included in the price of the baseline configuration.

6.4.2 Site B

6.4.2.1 Practice Demographics, Staffing and Background

Site B is an ophthalmology practice in Indianapolis, Indiana, owned by a physician who practices with his father, who is semi-retired. The practice was opened in 1963 by the current owner's father and assumed by the current owner in 1992. The two physicians operate the practice with three full-time staff members, including a receptionist, a medical assistant, and an optician. The current owner is the sole proprietor of the practice and owns the for-profit practice as a

professional corporation. The two physicians are male; the father is 74 and the son is 46 years old.

The younger physician interviewed is an electrical engineer and is technically trained and extremely computer literate. When he joined the practice in 1992, it was using a primitive scanning method to convert chart documentation into CPT codes using bar-coding technology. This concept did not work very well and they reverted to paper charts. In 1997, the practice adopted a practice management system that came with a primitive EMR, which they never used. While investigating new practice management systems, the physician found an EMR product that interested him. He subsequently signed a letter of intent with the vendor in 2000. As an ophthalmology practice, the office and its staff are generally comfortable with technology and routinely used scanners, printers, faxes, and computers before adopting the EMR. Other than office visits, the practice communicates with patients only via telephone.

6.4.2.2 Billing and Income

Site ID	MD Salary	Annual Gross Revenue	Annual Operating Expenses	Reimbursement Mix	Size of Patient Population	Practice Ownership Structure
Site B	Unavailable	Unavailable	Unavailable	Unavailable	Unavailable	Professional Corp.

6.4.2.3 EMR Research and Decision-Making Process

The physician states that he knew after residency that he would adopt an EMR. His main reason for adoption was to end the use of hand-written notes. The physician took the initiative to educate himself, mostly through online chat rooms through interactions with other physicians. He discovered the EMR he ultimately selected in the course of researching practice management systems. He did not conduct an extensive EMR research effort before purchasing his product, but instead opted to validate his selection after signing of a letter of intent. Although the physician signed his letter of intent in 2000, he did not adopt the product until 2003 because he was waiting for customizations and a new version of the software to be released. During this time he spent roughly 160 hours researching EMRs to validate his product choice. Most of the other products he examined use point-and-click methods for navigation; he prefers his system’s touchscreen capabilities. For instance, the legacy practice management system the office uses has an EMR system that does not have workflows that meet the needs of the staff, and it uses a point-and-click user interface, which the physician considers annoying. The office does not use this EMR because it is unusable and is not Health Level Seven (HL7) compliant.

As the sole decision-maker, the physician did not encounter any staff resistance, and he states that the staff have always supported his technology decisions. One staff member who had worked in a paper environment for 20 years embraced the EMR after seeing how much faster it made office work. The physician’s EMR research involved online chat rooms and observing vendor demonstrations at conventions. In total, he evaluated products made by 20 to 25 vendors. He did not visit any colleague or peer offices, nor did any vendors provide live demonstrations.

6.4.2.4 EMR System Characteristics

The total cost of the EMR system was \$30,000, which included the software licensing fee of \$7,500. In addition, the office pays \$1,400 in annual support fees and paid one-time fees related to hardware, Microsoft products to complement the EMR software, and other accessories. The entire cost was financed out of pocket. The physician uses the new EMR system along with a separate stand-alone practice management system. Because the two systems are not integrated, his staff must read the EMR charts and then use the practice management system to complete the billing function. The physician does not consider this to be a problem or a hindrance to his office's productivity. This practice was the vendor's first ophthalmology customer, and the practice was therefore very involved in customizing the product. The advantage this product had for the physician was that it replicated the office's workflows better than any other product he examined.

The vendor was on site for two and a half days to assist with implementation and training. Scanning old charts and information was very time-consuming and introduced inefficiencies during the first few months of adoption. The physician believes that the practice experienced reductions in accounts receivable during the initial implementation period. This was attributed to three factors:

- ▶ Customizing the EMR was distracting and labor intensive.
- ▶ Patient visits took longer as the practice adjusted to the EMR processes.
- ▶ Staying current with the EMR implementation required significant time and attention.

After 3 months the staff was able to use the EMR, and after 6 months the practice was back to "normal."

The EMR product chosen uses touchscreen terminals in each exam room. Each staff member has a unique EMR login that associates the users with their respective workflows tailored to their job functions. The EMR workflows guide the user through the steps to complete an office visit for a patient and to record the associated information. The office has a computer terminal in each of its four exam rooms. In addition, there are computers at the front desk, each physician's office, and the nursing stations. The computers in the exam rooms are desktops, but the office also uses hand-held touchscreen monitors. The practice purchased a tablet PC but has not used it for patient encounters and uses it only for other purposes.

The system presents a master screen that provides all office staff the status of every patient in the office, which exam room they are occupying, and what services they will receive. The EMR is accessible to the physician from any computer with Internet access—a feature that allows him to pull patient charts while he is at the hospital preparing for surgeries. The system also allows his staff to communicate in real time with messages that are not always patient-care related but are important to office operations.

Most tests ordered by the practice are performed in house. To order lab tests from outside labs, the physician puts the order into the chart, and the system generates an alert that is sent to the "to-do" list for logged-in staff. The office staff then calls the lab to schedule a test for the patient.

The system can also generate letters through the practice management system to be sent to labs. Lab test results are faxed to the office through its computerized fax machine, which automatically generates computer files of results and adds them to patient charts. Although the system is capable of more direct transmittal of test results, the office receives so few test results from external sources that they prefer the fax method. The system also allows for e-prescribing, but the office prefers to generate paper prescriptions for patients.

The system “learns” in that it will record the most frequently entered diagnoses and will automatically arrange options based on their frequency of use. The system checks for allergies, but the practice did not purchase the drug-drug interaction option because most of the drugs prescribed by the practice are topical eye drops, so they did not see a need for this functionality.

The office uses add-on software so the physician can make drawings in the chart as he formerly did on paper. The office also configured add-on software that can import photos into the EMR charts. The physician considers the requirement to import the drawings and photos by hand into the chart to be bothersome. The EMR system has the capability to record notes through a voice recorder into voice files which can be auto-sent to transcriptionists, but this office does not use transcription.

Comparing EMR to Paper Processes

The physician compared his EMR’s functionalities to paper processes. With respect to documentation, the physician considers the EMR to be far more efficient than paper processes. However, with respect to data entry, the physician finds writing on paper to be faster than typing. The benefit of the EMR in this process is that the EMR auto-codes the data entered, which is not feasible with paper records. With respect to basic results viewing functionality, paper processes and EMR processes are equally efficient. However, the EMR provides enhanced alerts and communications functionalities for results viewing that are rated as “Very Good” compared to analogous functionalities with paper processes (see Appendix C: In-Person Site Visit Instrument for description of ratings). The EMR medication ordering functionality is rated as “Very Good” compared to the paper processes based on the structured text templates, basic alerts, and printable prescriptions offered by the EMR. The EMR’s allergy check, drug interaction alert, and alternative drug suggestion capabilities are “Good” compared to the paper processes for medication ordering. Overall, the EMR system’s test ordering functionalities are “Very Good” compared to the paper processes in terms of ease of use and efficiency.

6.4.2.5 Actual and Perceived Benefits

Workflow Efficiency

The EMR system has improved overall intra-office communication, appointment scheduling, and wait times. The EMR generates letters and reminders, which saves time for the physician and other office staff. The physician believes that the EMR benefits a physician who sees more than 16 patients per day and allows busy physicians time to see more patients. Although EMR improves coding, manual checking is still required because of the specialty codes the practice typically uses. The physician’s free time has increased, and he can perform many tasks from home or the hospital.

Revenue Enhancement and Cost Savings

The practice has improved its patient maintenance and charge capture, which in turn has improved patient care and increased revenue. The practice's days receivable now reflect accounts, not charges. The practice can bill in real time, but this is not directly attributable to the EMR. The legacy practice management system helps with this, and the office continues to rely on that system for certain functions.

Quality

The EMR enhances quality of care by reminding the staff of patients who are due for in-office testing or other appointments, such as checkups. The practice did not purchase the drug interaction functionality because most often the drugs prescribed are topical eye drops. Consequently it is unknown whether or not any safety benefits could have been achieved. The physician views the potential of this system capability as poor because it requires extensive physician customization and upgrading. Patient satisfaction has increased, in part because patients are impressed with the concept. The EMR's video capability also allows the practice to educate patients with instructional videos rather than consuming staff time to give patients personal instructions and demonstrations. The physician believes that the true benefits of the system are improved access to patient information.

6.4.2.6 Barriers to Adoption

Although comparing vendors can be challenging, the physician advises peers that the long-term benefits of becoming well-informed going into the process are significant. He is satisfied with his product and has no plans to change products in the future. He thinks the difficulty of understanding the processes related to negotiating a contract with vendors can be a barrier for some and affect the success of their EMR implementation. For instance, if a physician does not purchase a support contract along with the system, he may not be protected against escalating annually support fees. This is a problem he was able to foresee and address.

Because the practice of ophthalmology typically involves expensive technologies, EMR costs were not considered a barrier to adoption. The physician did not see the technology itself as a barrier but cautions that other physicians who are not as familiar with computers may have trouble in making decisions on EMR products and vendors. Because every office is different, any EMR will need to be customized to accommodate the practice's workflow and processes. His office was the first ophthalmology office to implement the particular EMR he purchased and consequently the implementation required much customization. However, this was not considered a barrier to adoption.

6.4.2.7 Post-Implementation Observations

Since implementation, the vendor has not provided in-person support; all support has been provided over the telephone or the Internet. The practice is satisfied with the vendor's support, which includes phone support during business hours and 24-hour online support. The biggest challenge for the physician is remembering how to use all the system's capabilities.

The physician believes that trial and error and learning the system are the keys to making the EMR work for any practice. EMR implementation never ends because it continually requires upgrading and customizing. This practice upgrades hardware regularly to keep pace with needs and the state of the art. As cashflow allows, the practice has been rotating a computer out of circulation every 6 months.

The physician believes that no intervention on the part of the government and policymakers is needed because adoption will happen on its own. “There isn’t a doc out there who’ll want to write notes and pull charts” as EMRs continue to develop and gain popularity.

6.4.3 Site C

6.4.3.1 Practice Demographics, Staffing, and Background

Site C is a cardiology practice in Sheboygan, Wisconsin, owned by one physician. The practice operates several clinics including cholesterol, Coumadin, pacemaker, rehabilitation, and diagnostic clinics. The practice is staffed by two physicians for a total of 26 staff members. The office and its associated clinics are staffed by two nurse practitioners, five nurses, three rehabilitation staff, four technologists, two schedulers, two receptionists, five billing staff, and one office manager. The practice has been in operation since March 1999. The two physicians are both male and are ages 47 and 50+. One physician has been with this practice for 11 years and the other for 3 years.

Although this practice was not established until 1999, the owner has practiced in the community for many years. The practice has one location and regularly uses multiple forms of technology such as e-mail, fax, scanners, ultrasound, and nuclear imaging equipment. Staff members had prior computer experience; the office manager also had experience with EMRs. The office manager uses a computer daily for all of her business-related functions, including practice management, and describes the EMR as a tool to improve patient safety. Other than office visits, the practice communicates with patients primarily via telephone.

6.4.3.2 Billing and Income

Site ID	MD Salary	Annual Gross Revenue	Annual Operating Expenses	Reimbursement Mix	Size of Patient Population	Practice Ownership Structure
Site C	\$600K–900K (range)	\$10M–\$15M (billed)	Unavailable	Medicare – 62% Medicaid – 2% Private Ins. – 36% (all FFS)	5,000–6,000	Sole proprietorship

6.4.3.3 EMR Research and Decision-Making Process

This practice began investigating EMRs in 2002 and implemented in 2003. The primary motivation for considering EMRs was to improve efficiencies and workflow. The office manager was interviewed and explained that the practice wanted to stop “running around” looking for paper charts and wanted to improve physician efficiency. The practice was also interested in interfacing with labs. The office manager performed most of the research work and coordinated with the physician as time allowed. The selection was made one month after the research was

completed. The office manager and the physician owner of the practice were ultimately responsible for the decision to adopt.

The EMR evaluation process included speaking with other physicians with similar practices as well as consulting industry reports, medical management listservs, the Internet, and some peer-reviewed literature. The practice also used the Academy of Cardiology as a resource. Information gathered from peers played an important role in the selection process. The practice sought a product that was suitable to its specialty and that provided ready-made templates. The practice initially considered eight to ten products followed by a more detailed examination of three vendors. After narrowing its search to three vendors, the practice hired an information systems consulting group. The practice did not use a request for proposal (RFP) and did not receive any financial assistance from outside sources.

6.4.3.4 EMR System Characteristics

The total cost of the EMR was \$125,000, of which the software cost was \$80,000 and the remainder for hardware and consultant fees. The cost of software maintenance and upgrade was \$417 per month and interface support \$667 per year. In addition to these fees, the practice spends \$2,500 a month on outside IT support from a consulting company. The practice manager estimates that overall the practice spends \$30,000 per year, or 38 percent of purchase price, on system support and maintenance. The purchase was financed out of pocket. The purchase of the product included onsite training. An external IT consulting group conducted additional training after the vendor completed its training program. All staff were involved in all system training.

The EMR interface is intuitive and easy to use with a clean layout that lets users see many fields at once through layered folders. The system offers convenient preference settings, workflows, and interoffice communications. The office has integrated many of its diagnostic technologies into the EMR. The staff use both laptops and desktop computers in each of the offices, at the nurses' station, and in the exam rooms. The system has both administrative and clinical alert capabilities; however, the system does not prevent users from entering flawed data such as atypical heights for adults (e.g., 2'3"), and its clinical alerts are limited to drug-drug interactions. The system monitors patients as they move through the office and records all staff who have contact with a patient during a visit. The system requires physicians to sign off on areas to ensure proper supervision of patients and compliance with workflows.

The office manager stated that the system implementation was very stable from the beginning. Initial productivity losses were restricted to one week, and thereafter the practice experienced efficiency benefits. The office did not experience any lapse in revenue during implementation. It took the practice less than a month to improve the office processes using the EMR system. The training was adequate, and the cardiology templates simplified customization of the product. The staff accepted and embraced the system.

Developing an implementation plan allowed the practice to adopt the EMRs successfully. After selecting a vendor, the office manager worked with the vendor to set a timeline. The entire implementation took one year. The office manager championed the implementation plan, a process that involved significant time and coordination. The office planned a 6-month break

between launching the EMR and launching the practice management systems. Staff were trained before the system went operational. The operational staff were trained first, followed by the clinical staff. One staff member was very hesitant to adopt, having no experience with computers; however, after training she could use the system easily and now enjoys its benefits. As the staff learned the system, they established new workflows and processes. New hires can be trained on the system in 2 weeks.

College students were hired to scan paper charts into the system, beginning with charts for those patients who would be seen in the near future. The greatest challenge during this conversion process was ensuring that information was scanned into the proper areas of the EMR. Another implementation challenge was integrating the operations of the practice's many subclinics into the EMR. This effort involved working with the vendor. Overall, the practice is very pleased with its system.

Comparison of EMR to Paper Processes

The nurse manager was asked to compare the efficiency of EMR processes to their paper counterparts. This was the staff member who had been very hesitant to adopt the EMR. Overall, she found that the documentation was more efficient with the EMR than with paper, but she noted that typing notes is not necessarily more efficient than hand-writing them. For results viewing, overall the EMR system is more efficient than paper; however, when the office receives results by fax, the processes for both EMR and paper charts are the same. The EMR has improved medication ordering, and having an online version of the *Physician Desk Reference: Drug Guide* is a significant improvement over the paper process. The use of structured templates has generally improved test ordering compared to paper, although some test ordering processes have remained the same and require scanning paper.

6.4.3.5 Actual and Perceived Benefits

Workflow Efficiency

The practice now faxes prescriptions to pharmacies. The EMR's enhanced documentation capabilities let physicians complete notes within the system, which improves billing and reduces the transcription burden. The EMR has improved staff experience and job satisfaction by making the office less stressful and more organized. One staff member was able to work from home while on maternity leave. Since adopting the EMR, serving new patients takes the staff longer than it did with paper charts because a nurse now must enter patient history into the EMR as the patient relates it.

Revenue Enhancement and Cost Savings

Financial benefits have been in the form of paper savings, time savings, and efficiency. The EMR has significantly improved charge capture and has prepared the office for insurance company audits and any future pay-for-performance measurement.

Quality

The main benefit of the EMR for this practice is that it gives all staff easy access to information on all patients, so that when a patient calls or presents, any staff member can promptly give

assistance. The EMR also improves patient safety and quality by dictating tasks and tracking patients and their care. The practice used the EMR to create templates for emergency codes that allow staff to print out documentation to attach to a patient who experiences an emergency in the office and needs ambulance transportation. The office manager noted that the EMR differentiates the practice and is a mark of excellence that serves to further distinguish the practice from its competitors. No other local practices are using the system that the practice has adopted, and this enables the practice to differentiate itself from the competition.

6.4.3.6 Barriers to Adoption

This practice did not view the selection of an EMR as challenging and did not identify any barriers. This may be related to the consulting support it had engaged. The practice’s consulting organization helped the practice define the functional requirements, purchased the hardware, and handled the final negotiations. Although EMR product certification by a government or other entity may have influenced its decision, particularly if certified by the American College of Cardiology, a lack of certification was not a barrier to adoption.

6.4.3.7 Post-Implementation Observations

The practice cautions that when practices purchase an EMR they are buying a “shell” that will need significant customization before it can support the office workflows and needs. The staff advise purchasers of EMRs to keep open minds and to be persistent with their implementation.

6.4.4 Site D

6.4.4.1 Practice Demographics, Staffing and Background

This practice has been in operation since 1997 and is a multi-specialty practice in internal medicine, pediatrics, and family practice. There are a total of 16 staff in the practice, 5 of whom are physicians (3 internal medicine/pediatrics, 2 family practice) and 1 a nurse practitioner. There are two RNs, four medical assistants, one phlebotomist, an office manager, a receptionist, and two billing staff. All the physicians are in their early 40s. The practice is for-profit and is owned by three managing partners.

The office manager uses a computer every day, which is common for staff in the practice. The office uses a practice management system, e-mail, fax, scanners, and a web portal. The web portal has been operational for 2 months. The office communicates with patients through telephone, fax, e-mail, and the web portal.

6.4.4.2 Billing and Income

Site ID	MD Salary	Annual Gross Revenue	Annual Operating Expenses	Reimbursement Mix	Size of Patient Population	Practice Ownership Structure
Site D	~\$120K	\$2.1M	\$1.8M	Private non-HMO – 59% Private HMO – 32% (9% capitated) Medicaid – < 2%	13,500	Partnership (3 managing Partners)

6.4.4.3 EMR Research and Decision-Making Process

The office adopted an EMR in May 2004, after evaluating and investigating EMRs for approximately a year. The practice is a “beta” site for its vendor and has influenced many others to adopt an EMR after seeing this system. The goal with adopting an EMR was to reduce costs and overhead. EMR adoption was led by a physician champion who had prior experience with EMRs during his tenure at a hospital. Some of the physicians were initially opposed because of the system cost, but the physician champion convinced them to adopt by educating them on the benefits of EMRs. One of the staff in particular was resistant to the idea because she was unfamiliar with computers in general; however, it was decided that through training she would adapt to the new system. The three managing partners and the office manager were the decision-makers. The physician champion relied on a variety of sources for information on EMRs including peer-reviewed literature, industry reports, consultations with colleagues, and product demonstrations.

6.4.4.4 EMR System Characteristics

The practice purchased an integrated EMR and practice management system. The system required customization, and the vendor configured the templates to meet physician needs. Users can create their own templates, a feature that the nurses have used. The software cost \$57,000, with additional quarterly fees of \$1,500 for EMR maintenance and support. The purchase was financed through a loan. In addition to the software and maintenance costs, the office purchased wireless laptops and other hardware. The office also has a contract with a separate vendor for general IT support. The office pays this separate vendor a fixed annual fee. This company helps with upgrades, server issues, and general technical support.

The office received one week of training and was totally paperless on day one of the implementation. It took 6 to 7 months to convert from historical paper charts, and in doing so only active patients were entered into the system. The office is very pleased with the system.

All of the physicians have adopted the EMR. The office has computer stations in each exam room with physicians carrying wireless laptops. Firewalls provided by the vendor ensure security of the data. The interface has popup alerts, reminders (e.g., billing alerts), and color-coded scheduling that indicates patient status. Nurses monitor the schedule, and time durations are auto-calculated to show how long a patient has been waiting. Patient charts look like file folders with tabs for different chart areas. Any staff member can access any of the patient charts. The system generates both administrative and health-related reports such as “How many 15-year-olds have diabetes?” The system indicates when telephone or e-mail messages are waiting for individuals in the office. The practice receives lab and test results from two companies, one of which is interfaced with the EMR and provides results electronically that are automatically attached to charts. The other company does not have this interface, and results are faxed to the office and uploaded into the charts.

Comparison of EMR to Paper Process

The office manager was asked to rate some of the current system’s usability as compared to paper charts. The EMR processes for completing documentation and results viewing were rated

as “Very Good” in terms of ease of use and efficiency compared to the paper processes for these functions.

6.4.4.5 Actual and Perceived Benefits

Workflow Efficiency

The web portal has already benefited the office, after only 2 months of operation. The morning of the site visit, the practice had received 47 messages through the portal, and all were responded to in under an hour. The practice noted that this process would have required more time if these messages had been received and returned via telephone. Patient use of the web portal is increasing, and the office is very excited about it. The EMR lets any staff in the office help a patient on the phone from any location in the office. Computer-faxing allows for point-and-click responses to tasks. Prescriptions are faxed directly to the pharmacy. The EMR allows all staff access to information that is time-stamped and that contains valid data. The EMR has also improved quality of life for staff by allowing staff to access records from home. A summary of workflow efficiencies includes:

- ▶ Decreased number of chart pulls
- ▶ Improved clinical documentation—notes clear, time-stamped, legible
- ▶ Improved reporting processes for drug refill and lab results
- ▶ Decreased patient wait times
 - Down to 10 minutes from sign-in to visit start (compared to 30–40 minutes before EMR implementation)
 - Charts easily accessible
 - Electronic insurance verification
- ▶ Increased practitioner quality of life and staff satisfaction—one RN is able to work from home now.

Revenue Enhancement and Cost Savings

The office was able to reduce its medical records staff from three FTEs to one and a half. The front desk staff was reduced by half, as was the nursing staff. In total, with EMR adoption the office reduced its staff by six people, a savings of approximately \$40,000 per year. The office experienced revenue enhancement from improved charge capture and believes that the EMR differentiates it in the marketplace. The practice enjoys a 5 percent discount on malpractice insurance costs due to EMR adoption. The practice has reduced its costs associated with records storage, paper supply, and personnel as a result of EMR adoption. The office has not experienced drug savings, reduced radiology use, or reduced laboratory use. However, the office now gets timelier lab results from the labs with which it interfaces. A summary of revenue enhancements includes:

- ▶ Reduced transcription costs
- ▶ Reduction in billing errors—the computer can detect errors easily.
- ▶ Improved charge capture—access to charts is faster, so claims can be analyzed (and submitted) more promptly.
- ▶ Increased revenue from increased patient or visit volume

- ▶ Increased coding levels—the EMR establishes workflows and prompts that lead to more thorough patient interactions documented for coding justification.
- ▶ Reduced days in receivables—billing is electronic and timelier.
 - Reimbursement is 20–25 days vs. 90 days before.
 - Medicare reimbursement is down to 2 weeks.
- ▶ Office expansion—the EMR allowed for a second office suite to be opened with little remodeling effort
 - New suite for patients had been used as a billing office prior to EMR.

Quality

The EMR has also allowed the practice to enhance the patient experience. The system can automatically generate letters for patients such as immunization reminders. Through the web portal, patients can access their own medical information and test results, communicate with physicians, and request appointments, referrals, and refills.

6.4.4.6 Barriers to Adoption

The office manager noted that at the beginning of the research and evaluation process the managing partners were resistant to the physician champion's suggestion of an EMR. These partners thought the cost of the system to be prohibitive. Through education and demonstrations of EMRs, the champion was able to overcome this barrier.

Some of the physicians in the office do not use the EMR templates to their full potential but type their notes instead. This is a challenge to maximizing the potential of the EMR. Two of the RNs who did not have any experience with computers were very resistant to the EMR adoption. These RNs underwent the same training as the other employees and were able to adopt the system with the other staff. Now these same RNs "love the system." The office manager runs productivity reports every week through the system to manage the office. She can see what notes have been completed and locked and are ready for billing. This allows her to manage the physicians who are not using the EMR system to the extent possible.

6.4.4.7 Post-Implementation Observations

After EMR implementation, the staff unanimously agree that they would never return to paper charts. The staff's satisfaction with the EMR is "tremendous," even of those who were initially resistant.

6.4.5 Site E

6.4.5.1 Practice Demographics, Staffing and Background

Site E is a pediatrics practice in Bridgeport, Connecticut, staffed by 3 physicians, 3 nurse practitioners, and 15 support staff, including an office manager, business manager, an RN, a referral staff member, receptionists, and medical assistants. The practice opened in 1989 and moved to a new location in 2003. The practice is for-profit and is owned as a private corporation by a husband and wife team. The practice sees many special-needs children and serves an inner-

city urban population. The practice has been paperless since 1999. Two of the physicians and nurse practitioners are female and three male, and all are between the ages of 30 and 50.

The physician champion believes that his practice was one of the first physician offices in the country to become truly paperless. This physician had experience with some rudimentary computerized records during his residency and designed a computerized oncology system to address his concerns over manual calculations of critical dosages. Before adopting an EMR, the office used note writing and dictation systems as well as computerized records that the physician described as precursors to EMR products. The office maintains a web portal, but only communicates with patients via telephone and mail. The physician has consulted with vendors in the development of EMRs and believes EMR adoption will help physicians improve the quality of care delivered to their patients.

6.4.5.2 Billing and Income

Site ID	MD Salary	Annual Gross Revenue	Annual Operating Expenses	Reimbursement Mix	Size of Patient Population	Practice Ownership Structure
Site E	Unavailable	Unavailable	Unavailable	Medicaid – 50–60% Private (HMO and PPO) – 40% (0% capitation) Uninsured – 5% Out of pocket – < 2%	10,000	Professional corp.

6.4.5.3 EMR Research and Decision-Making Process

The physician champion of this practice’s EMR adoption took over this practice in 1989 and immediately implemented a practice management system. In 1993, the physician explored computers with capabilities such as dictation and migrated the office to a template system that transcribed notes. Following this, the office adopted a rudimentary EMR product that did not have a database and as such was described as an automated paper process. A true EMR, in the physician’s opinion, was implemented in 1999. The selection process began with the physician visiting trade shows and military installations that had implemented the first EMR-type systems, researching products, and developing a list of the 20 largest vendors with the greatest market shares. The physician limited his research to the 20 largest companies because he wanted to consider only those he considered stable. The physician observed that most of the vendors at the time were uninterested in small physician practices as clients. The physician seriously considered three products, and the selection process involved many demonstrations and the input of all the office staff. The physician asked vendors for their entire client lists and called every client to verify the reputation of the product and the company. The entire staff unanimously selected the final product.

The physician felt it was easy to evaluate where each company focused and what their strengths were at the time. He cautions that trade shows and demonstrations make all products “look good” but that the evaluation process is challenging. The overall research and evaluation process took 6 months, which included the negotiations with the vendor.

6.4.5.4 EMR System Characteristics

In 1999 the practice spent \$150,000 on software and other implementation costs. The office pays an annual fee of \$15,000, which includes all support, upgrades, and maintenance. The EMR and the practice management system are from separate vendors and are integrated. In 2003, the practice switched to an application service provider (ASP) model and now pays \$800 per month for telecommunication charges as well as \$1,000 in phone bills associated with Internet costs. This purchase was financed out of pocket.

The EMR system has an intuitive user interface, is customizable (down to individual user preferences), and provides easy access to data and analysis tools. Forms are fluid, and the system has prompts and reminders. The system's built-in templates facilitate workflows and enable easy and accurate documenting. All phone calls are documented electronically, as are such things as letters and school forms. The system offers drug-drug interaction alerts and diagnosis alerts, and task lists track all patients that a physician contacts in a day.

The office has a web portal and integrates its systems with one lab company so that all results are automatically imported into patient charts. In addition, the system interfaces with the local hospital laboratory results system.

The physician's philosophy is to have the best of breed in any functionality. Consequently, the office purchased many add-on products to complement the EMR system. For instance, the office purchased a patient education product that enables the practitioners to access to drug information online and print out materials during office visits.

The vendor planned the implementation and conversion plan for the practice and set out a 3- to 4-month schedule for preparations. Before going "live," the office collected data and customized forms to prepare for implementation. The vendor provided three trainers for 2 weeks during the initial stages of implementation. The vendor would have remained on site longer for no extra charge if the office had requested it. After implementation, the practice needed to convert existing paper records to electronic ones, and this part of the process was challenging for the practice. The conversion process took 18 months, and physicians and nurse practitioners had to manually enter data. For the first 3 months, processes took more time than normal. After that, the office reached steady-state. After 6 months, processes took less time than they had before EMR implementation.

6.4.5.5 Actual and Perceived Benefits

The physician believes that the main benefit of an EMR is that "computers do not make mistakes and pencils do." He believes that offices without EMRs are unsafe. The physician interviewed agrees that EMR benefits include improved patient safety, quality of care, cost reduction, improved work flow, revenue enhancement/charge capture, differentiation in the marketplace, and improvements in physician quality of life. Since implementing the system, the practice has experienced many benefits such as the following:

Workflow Efficiency

- ▶ Overall efficiency
 - Office sees a patient within 5 minutes of appointment time and raised expectations of patients. Office staff can track patients in the office through workflow monitoring.
 - Office can see 70 patients per day.
 - Office is generally organized and efficient.
 - The 2–3-week wait period for an appointment is markedly shorter than those of its competitors.
 - A total patient visit is down to 20 minutes—this includes time for charting, coding, filling in school forms, referrals, and prescriptions.
- ▶ Elimination of hand-writing and transcription
- ▶ Ability to track such things as lot numbers for vaccines
- ▶ New staff members can be trained to use the system in 4 hours.

Revenue Enhancement and Cost Savings

- ▶ Office does not under-code out of fear.
 - There is 100 percent charge capture because codes are entered during charting.
 - Staff are confident in coding for all services provided because of increased documentation.
 - The audit record is 99–100 percent on the insurance companies' grading scales for documentation.
 - The practice has been told by insurance companies that its documentation is the best they have seen.
- ▶ The office is able to operate with only one RN—most offices cannot.
 - The office hires other RNs but on an hourly basis, and these are telecommuting staff who work at home—the EMR enables this arrangement.
 - The office is open 10 hours per day, and the one full-time RN works 8 of those hours.
 - There is overall direct financial savings and improved job satisfaction for the nurse staffing.
- ▶ Accounts receivable is now 26 days and is the top of the industry (the office does this electronically).

Quality

- ▶ The office has increased potential for patient capacity but has elected to keep the lower volume and spend more time with patients to provide a higher level of care.
 - Spending more time with patients leads to retention of patients.
 - The office sees many chronically ill children, and the EMR enables better quality care and more time with patients.
- ▶ Distinction in the marketplace—patients drive over an hour to come to this practice because of the level of service.
- ▶ EMRs let physicians improve delivery of care through the availability of data.

- For example, they can run a report on patients due for flu vaccine, organize a clinic, auto-generate letters, schedule the clinic, and then vaccinate as many as 300 patients in a day.

6.4.5.6 Barriers to Adoption

This practice encountered some challenges in its implementation and identified potential barriers for other adopters. The physician found that each vendor has its own price structure (e.g., which functions are included, whether or not maintenance is included), making it difficult to compare prices of different products and services. He noted that most vendors charge 20 percent of the overall price for an annual maintenance fee, but users need to ask if the fee includes upgrades, because sometimes it does not. Looking for hidden costs is a challenge for purchasers. The conversion from paper to EMR is very challenging, and adopters should expect many “glitches” in implementation. The implementation period typically causes a temporary slow-down, and this period can deter many would-be adopters who are considering EMRs.

The physician interviewed noted that although comparing vendors was difficult, it was not a barrier for this practice. Site visits can help practices assess vendors adequately. The physician pointed out that there are no standards and no migration paths/conversion paths between any two EMRs. This means that practices that invest in one product and then want to change to another cannot do so in today’s market, and this may be a deterrent to adoption. Although the government is currently trying to create standards, this effort has not changed the current situation for purchasers.

The physician believes that user misunderstanding is a barrier to adoption. Another barrier is achieving unanimous buy-in from all physicians before entering into the adoption process. Some may object because of cost; others may have computer phobia; or older physicians simply may not want to change the way they do business. All of these barriers need to be overcome to obtain the buy-in needed for successful adoption. Once the decision has been made, all staff must be truly committed to the implementation process. The physician advises that an implementation plan is critical to successful adoption, and staff must be committed to one. He suggests that smaller physician groups may be able to achieve this more easily than larger ones.

6.4.5.7 Post-Implementation Observations

Although each product has its strengths and weaknesses, the physician believes that “any EMR is better than no EMR.” He cautions that if physicians wait for the perfect EMR, they will be waiting forever. The quality gap between offices with EMRs and those without is growing, in his opinion. He believes that many physicians can be egotistical in their resistance to a machine helping them to improve patient care.

The physician noted that there are many differences between current products and services and those that were available in 1999. Physicians can now pay a monthly fee for software use and use ASP to avoid purchasing hardware, thereby reducing up-front costs. The physician believes that today no practice should be purchasing in-house servers. Throughout the practice’s experience with EMRs, the office had to purchase add-on products from other vendors to assemble the entire

package of functionalities desired. It was necessary to work with the vendor to get these add-on products interfaced with the EMR system. Convincing vendors to pay for interfaces themselves means persuading them that it is in their best interest to do so. For instance, in the case of convincing the EMR vendor to build an interface for the practice’s lab vendor, the physician had to demonstrate to the vendor that it was a cheap and easy endeavor that would then allow all other EMR users to interface with this particular lab, a widely used laboratory company. The office was looking forward to improved prescribing processes, but no pharmacies in the state of Connecticut will accept faxed prescriptions (due to regulation), so the office prints prescriptions for patients.

The physician now spends five hours a week on EMR/computer maintenance–related tasks, primarily because he enjoys doing it. However, he has time for these maintenance tasks because EMR has made patient care more efficient and he spends less time at the office overall. The office conducts ongoing training, and he uses staff meetings to continually remind staff to use all aspects of the EMR’s functionalities.

6.4.6 Site F

6.4.6.1 Practice Demographics, Staffing and Background

Site F is an obstetrics and gynecology practice located in Jesup, Georgia, a rural area of 9,000 persons in a county of 22,000 persons. The practice is owned and operated by one physician who has been in solo practice since August 2003. The office has one nurse practitioner, three LPNs, one physician assistant, one sonographer, one receptionist, an office manager, an assistant office manager, and billing staff. The practice is for-profit and is owned under a corporation that the physician owns. The office has adopted an EMR and has been using it since its inception in 2003. The physician is male and has been with the practice since 2003; he previously served in the Army for 20 years.

The physician explained that he has adopted an interactive product that enhances the charting experience instead of duplicating a paper process. The physician had some prior experience with EMRs in the military and became convinced that with the right model and functionalities EMRs could be powerful tools. The physician is very computer-literate and has done much of the programming of his system himself. He is the computer administrator at his office and views computers as his hobby. The office communicates with patients only through telephone and mail. It established a website, but patients in this rural community did not use it.

6.4.6.2 Billing and Income

Site ID	MD Salary	Annual Gross Revenue	Annual Operating Expenses	Reimbursement Mix	Size of Patient Population	Practice Ownership Structure
Site F	Unavailable	\$1.04M	\$1.1M	Medicare – 13% Medicaid – 32% Private Ins. – 36% (all FFS)	3,431 last year	Professional corp.

6.4.6.3 EMR Research and Decision-Making Process

The physician's primary motivation was to improve quality of care—he never believed that the product would enhance revenue. The physician began investigating EMRs 6 months prior to adoption and conducted detailed evaluations of products for 3 months prior to purchase. The office manager was the lead in the effort, and the physician initiated the search. The physician relied on websites such as the Academy of Family Medicine's practice website. The office manager led the vendor negotiations. The physician and office manager visited a colleague who was influential in the decision. They evaluated 25 products and viewed demonstrations of 5 before purchasing an EMR. The physician and office manager made the decision on their own prior to hiring any office staff.

They selected the product they considered to be the best of breed in EMRs and in practice management systems. The two systems are integrated. The decision to purchase the EMR product was based on the product's ability to replicate and enhance workflow processes. The physician found it easy to use, and it had local adaptability and integrated with the practice management system they had selected. The physician did not want to change the way he practiced in order to use an EMR.

6.4.6.4 EMR System Characteristics

The physician described the vendor as very honest and sincere during the week-long negotiation process. The hardware costs included hardware that was needed for the startup of the office and totaled \$42,000. The EMR software cost \$20,000 and the practice management software \$12,000. In total, the system cost \$60,000, with \$6,000 in maintenance for both systems. The price included onsite and continuous online training. The purchase was financed as part of a loan for the practice's overall startup costs.

The physician wanted a reliable product with prompts (e.g., that a patient is due for blood work or a mammogram), reminders for nurses, and alerts to remind staff of workflow processes. The current product has these functionalities and consequently improves patient care. The office receives lab and test results on paper and scans them into the system. The office prefers to have the EMR generate paper prescriptions for patients that the physician signs—this counters fraud and abuse in the view of the physician.

The office experienced few implementation problems as it began use of the system almost concurrent with practice inception. The new staff spent one week learning the system and prior to implementation had used paper charts for 3 months. The office experienced little or no transferal of data from paper to the EMR. Most of the staff came from the hospital setting with no prior EMR experience.

Currently the office experiences minor glitches with the system every two weeks or so, and the vendor can address these issues by phone. Although many vendors charge for service and questions, this vendor offers continuous support. The physician can modify and customize the workflows of the product as needed on his own.

6.4.6.5 Actual and Perceived Benefits

Workflow Efficiency

The ability of the physician to pull a chart when a patient calls for a refill and see which pharmacy to use improves his personal efficiency. Decreased charting time has led to improved physician quality of life.

Revenue Enhancement and Cost Savings

The EMR has provided a clear benefit to the practice by allowing thorough and fast documentation and reporting. The office has also experienced a 10 to 15 percent increase in level of coding. In one instance, the practice's insurance company did not wish to reimburse it for a certain procedure, citing it as unnecessary. The EMR enabled the practice to provide appropriate documentation that allowed reimbursement. The company complimented the physician on his ability to document and demonstrate his need.

Quality

The EMR allows the staff to provide higher quality care and focus on educating and caring for the patient rather than on administrative work. Terminals in the exam rooms let patients see such things as images and graphs, and they appreciate the technology. Overall, the office has improved patient safety, quality of care, and patient satisfaction.

6.4.6.6 Barriers to Adoption

The physician is a local EMR advocate and has encouraged the local hospital and pediatrics groups to consider EMRs so that the town's community may be more integrated with respect to medical information sharing. He believes that the overall resistance to EMRs among the county's physicians is due to the older population's fear of computers. Barriers for other doctors may be the perception of cost, of difficulty in using an EMR, and that they will have to change their workflows to match the computer. The physician explained that EMRs may not save money. He is not sure if the practice has experienced a quantifiable dollar benefit as he has no baseline to compare.

6.4.6.7 Post-Implementation Observations

While this was not a motivating factor for the physician to adopt, he has not realized improved lab or prescription processes since implementing. The labs the physician uses do not accept electronic orders, and results must be scanned in. He also does not use the e-prescription functionality as he likes to personally sign prescriptions.

6.4.7 Site G

6.4.7.1 Practice Demographics, Staffing and Background

Site G is a single-specialty family practice in Wilmington, Delaware, and is self-described as the state's leading diabetes provider. The practice was established in 1941 and has been in continuous operation. The physician we interviewed has been with the practice since 1974. The practice's clinical staff is currently made up of five physicians, one nurse practitioner with a

certification as a diabetes educator, one physician assistant, and one exercise therapist. The practice additionally has a separate division that practices pharmacological research. The practice is for-profit and is a professional association with the physicians as partners. Three of the physicians are male, ages 45, 43, and 71. One is female and is 30–35 years old. Three of the physicians have been with the practice since their residency, and the fourth returned to part-time practice three to four years ago post-retirement.

The physician interviewed became the managing partner in the practice in 1980. He moved the office to a practice management system in 1982. The physician champion is the medical director for the Delaware healthcare quality improvement program and is the medical director for DoQ-IT (Doctors Office Quality Information Technology) at the state quality improvement organization. The practice used the same system until a few years ago; this system used a scanner card to capture information. Three to four years ago the practice looked into the EMR product that its practice management vendor offered. In May 2003, the practice purchased an EMR product to interface with the practice management system. The system “was a disaster” (cost the practice ~\$100,000) and was abandoned in May 2005. The practice subsequently implemented a new practice management system without an EMR. The practice has only recently recovered financially from the experience with a poor EMR. Six to eight months ago, the practice began again exploring the possibility of an EMR. The practice currently uses a practice management system and an e-prescribing system complete with a web-based operation that allows for e-prescribing that was granted to the practice as a participant in a state demonstration.

6.4.7.2 *Billing and Income*

Site ID	MD Salary	Annual Gross Revenue	Annual Operating Expenses	Reimbursement Mix	Size of Patient Population	Practice Ownership Structure
Site G	\$105K (avg.)	Unavailable	Unavailable	Medicare – 20% Medicaid – 20% Private Ins. – 60% (all FFS)	14,000 (10,000 seen regularly)	Professional association (MDs are partners)

6.4.7.3 *EMR Research and Decision-Making Process*

It took the practice approximately three months to research products and choose a new vendor for the practice management system and EMR combination. An RFP was never considered as a means of selecting a vendor, because the practice did not want to take time to write one. A consultant was not considered either. The physician led the effort to research and decide upon a product/vendor. Based on prior experience with researching products, the physician felt confident in his ability to identify vendors with quality products.

The practice formed a decision team composed of two MDs, the head nurse, a receptionist, and the office manager. The team read literature, reviewed sources, and spoke with peers for recommendations. They developed criteria for evaluating the systems. One of their primary requirements was an EMR system with local service—a company that was not local and could not provide immediate, local service was not acceptable. After researching and developing criteria, the decision team observed demonstrations and selected two products for additional

review. The team conducted site visits to practices they considered comparable to their own and learned how to use the products from peers without the pressure of vendors present. The team unanimously voted on the product that was chosen. The contract with the vendor was signed in March, and they anticipate implementation to begin in June or July 2006. The lead physician on the decision team spent a few hours a week, five to six hours at most, researching products.

The usability of the system was cited as one of the main features of the selected system—the system replicated the existing processes of the practice. The site visit with a peer practice was the most influential factor for the decision team, allowing each of the members to see, with patients present, how the system performed the various work functions.

6.4.7.4 EMR System Characteristics

The product will cost approximately \$100,000 in acquisition costs, with an annual maintenance fee of 20 percent of purchase price per year (\$1,500 or less per month). Training and installation is included in the one-time costs. The practice needed to expand its wireless network and purchase PCs and tablets for the clinical staff to accommodate the new system. The practice did not have computers in the exam areas and only a few of the offices had PCs prior to the EMR purchase. The practice is also purchasing a server, but one that has a robust hourly backup in place; the vendor can provide service through the ASP temporarily.

The new product has the ability to import lab results from all of the major laboratory companies—a feature that was not available a few years ago—eliminating scanning and allowing for data mining. A local cardiology and radiology group that the practice works with is implementing an electronic system that will be interoperable with the practice's EMR.

The system is customizable and comes with such features as decision support and progress notes. The practice is eager to access the web from the exam room. The EMR will integrate with the practice management system and will download patient demographics automatically. Adoption will eliminate all paper bills and will simplify all billing processes. The system can automatically generate and auto-address the annual flu letters to the specified populations based on Centers for Disease Control (CDC) recommendations.

6.4.7.5 Expected Benefits

Workflow Efficiency

The new product can alleviate the practice's current situation, described as “drowning in paper.” The office currently receives two to three inches (unfolded) of clinical mail per day in the form of documents such as lab reports. The practice hopes that its system will eliminate use of paper. They believe the EMR will allow staff to simultaneously access a patient's chart. The practice expects a savings in physicians' time. One nurse refuses to work in a practice that does not have an EMR. It is expected that having the EMR will simplify the nurses' lives. The physician we spoke with is looking forward to accessing patients' charts from home while he is on call.

Revenue Enhancement and Cost Savings

Paper causes billing to be up to one month behind, and when the office is short-staffed the problem is worse. The practice expects the EMR to address this problem. The practice has a chart room, and has just converted the third exam room into another chart room. The practice is using valuable patient space for storage and is looking forward to converting the space into examination rooms. Another significant benefit will be the ability to generate and produce the practice's own data. Administrative data from insurers has been grossly inaccurate. The practice had an experience with an insurer whose data showed the practice to be poor in diabetes care, which contradicted the practice's own data.

Quality

The practice's pharmacology research requires substantial data mining that is impossible with the current state of 800+ paper charts. The physician hopes that the system will have a significant impact on the practice's ability to do research. Without adequate information, the practice is unable to properly care for patients. The physician hopes that the system will also allow the practice to look at quality of care in new ways through access to data. The ability to see patients' charts at home while on call will help the practice deliver better care to patients who call or who end up in the emergency department.

6.4.8 Site H

6.4.8.1 Practice Demographics, Staffing and Background

This is a for-profit sole proprietorship located in Chicago, Illinois. The owner and physician is a pediatrician with two office locations, each of which has been in continuous operation for 14 to 15 years. The physician is male and is between 51 and 65 years old. The offices are staffed by the physician, who splits his time between the two locations, and his staff of one medical assistant and one receptionist. This practice has completed an evaluation of EMRs and has signed a contract with a vendor to implement a system.

The physician interviewed at this site described EMRs as "a way to get rid of paper." He also noted that the 2 percent discount on malpractice insurance provided to sites with EMRs is a significant incentive for his practice to consider EMRs. He views EMRs as systems that allow for the storage of medical information, including labs and tests ordered, on each patient. For this physician, an EMR should be available from "anywhere," provide templates for complete patient assessment, provide advice to the clinician, and keep information safe. The physician uses a computer daily for e-mailing, work-related functions, and online courses. The office communicates with patients by phone only and would communicate with patients via e-mail, but the practice is not reimbursed for this form of communication. The practice uses fax for office functions and receives all lab and other test results by fax.

6.4.8.2 Billing and Income

Site ID	MD Salary	Annual Gross Revenue	Annual Operating Expenses	Reimbursement Mix	Size of Patient Population	Practice Ownership Structure
Site H	\$200K– \$300K	\$400K– \$500K	\$300K	Medicaid – 40% Private Ins. – 50% (HMO fully capitated and PPO FFS) Cash – 2%	5,500 per year	Sole Proprietorship

6.4.8.3 EMR Research and Decision-Making Process

The physician began to consider adoption 4 years ago, and the primary driver was paper reduction. The office stored paperwork onsite, and the storage needs were getting “out of control.” The physician also wanted to safeguard records after an experience with a flood that destroyed paper records. The practicality of being able to quickly record data in a minimal amount of time appealed to him. The physician initiated the adoption process and spent approximately 3 months researching EMRs over the course of several years, working on the issue in “bursts.”

The physician was influenced to adopt by a friend and fellow pediatrician who had an EMR system. He then began to research and used an analysis found in a “throwaway” medical economics journal. This analysis provided a useful comparison of specific EMR products. He researched and conducted online trials of several products. Two of the less expensive products seemed promising, but they did not offer the functionalities he wanted and some were not geared toward pediatrics. Some were “too cheap and too simple to believe” (e.g., one was available for \$900). He realized that he would need to make a significant investment to obtain the functionalities he wanted. He also realized that the process of evaluating his own needs and the capabilities of products was too difficult to take on alone. The physician hired an IT consultant to guide him through the purchase and implementation of his system.

The physician found two systems that addressed his needs; one of them happened to be the same one his colleague had. He contacted the vendors and one came out to do a demonstration at his office. The other product he was able to use at a colleague’s office. The physician felt more comfortable with the information flow and interface of his colleague’s system. The system could be set up for particular practice types, and users can click through to different screens instead of typing. He wanted to connect with an electronic billing system, as he currently sends his bills to a company for processing.

6.4.8.4 EMR System Characteristics

In total, implementation will cost approximately \$30,000 to \$40,000. Half of the costs are for hardware, half for software.

Initial purchases include a large server with backup tapes and a modem to connect to an ISDN line (both offices were connected to the vendor). One office has stationary computer systems for the front desk—one for each exam room and one for the medical assistant area—all of which are

linked. The other office has a modem and three laptops—one for the front desk, one for the physician, and one for the medical assistant. These have wireless connections, and the office has a printer and scanner to scan in old paper records.

The physician describes the new functionalities of his EMR system as including:

- ▶ Medical history
- ▶ Records
- ▶ Physicals
- ▶ Storage of information based on type of visit
- ▶ Storage of lab and test results in the system—lab results can be received directly into the system.
- ▶ Decision support—allergy reminders, drug interactions, etc. (however, these were not deciding factors for him)

The physician plans to connect to the hospital to view diagnostic images online. His system can also communicate with pharmacies about prescriptions either online or by e-mail. The physician likes the ability to click and print prescriptions through the new system.

6.4.8.5 Expected Benefits

The physician articulated the following benefits of the EMR that he hopes to realize through adoption:

- ▶ Bringing the practice up to speed with current HIT trends
- ▶ Organizing the office
- ▶ Improving the flow of information
- ▶ Decreasing errors
- ▶ Accessing information from both offices—this was difficult with paper records—leading to better care
- ▶ Links to billing reducing the time for checking on account status and providing notices for patients with outstanding balances (will help close accounts more rapidly)

6.4.8.6 Barriers to Adoption

During the research process, the physician felt that the vendors “lived in another world” and were too technical. He spent much time understanding the groundwork of his system and understanding what the vendors felt were simple concepts. The physician felt that he did not get much support from them because they were “too technical.” He had a limited budget for this purchase, so over time he gradually acquired computers, servers, and software. He made some errors with these purchases that were costly to correct. One thing that facilitated adoption happened somewhat later in the process: he found and hired an IT consultant to guide him through the process. This person was an independent consultant who worked on the medical records technology for the main hospital in Chicago. This consultant helped him overcome barriers of technical understanding and functionality selection.

The physician does not believe that the EMR will offer any real competitive advantage. He believes that the EMR could make practice more complicated and that there is a level of uncertainty throughout the process until implementation is complete. The physician has several colleagues who cite uncertainty as a barrier to adoption. These colleagues are waiting to see how this practice's implementation turns out before making their own decisions. He feels that they will be behind the curve because systems will be even more complicated when they do implement.

7.0 Proposed Economic Framework for EMR Adoption

In previous chapters, we described the literature on EMR adoption as it relates to small practices and models of technology diffusion that arise from the traditions of sociology and economics. In Section 5.6, we identified four critical themes relevant to EMR adoption:

- ▶ **EMR costs and benefits are important motivators of physician adoption.** The literature also suggests that physicians may be influenced by both an expectation of net financial benefit and a desire to deliver safer and better care.^{761,762,763}
- ▶ **Factors such as physician and practice characteristics appear to indirectly affect calculations of costs and benefits.** These characteristics vary in the strength of their correlation with adoption, however, and those that have some level of correlation include practice size, practice ownership, manner of reimbursement (capitated versus fee for service), practice type (specialty versus primary care), practice location, physician age, and physician specialty.^{764,765,766}
- ▶ **Physicians face considerable uncertainty in the realization of costs and benefits.** Uncertainty about costs, benefits, and net benefits have been cited as a barrier in the survey literature.^{767,768, 769}
- ▶ **Information can play a key role in lowering uncertainty.** The literature also provides evidence that physicians, like other prospective technology adopters, are influenced by social networks. These networks are important channels of information relevant to choosing a particular technology and understanding the costs and benefits associated with that technology.

Based on these findings, we developed a preliminary economic framework that combined the relevant elements from the EMR adoption and technology diffusion literature. Subsequent to developing the preliminary economic framework, we conducted visits to eight physician offices to test our hypotheses and validate the elements in our preliminary framework. We used the findings from the site visits to update the framework. In addition to validating elements of the preliminary economic framework, the site visits yielded additional insights, including the following:

- ▶ The importance of previously accumulated human capital that can reduce the costs associated with adoption
- ▶ The uncertainty associated with EMR technology and the importance of information from peers in reducing this uncertainty.

In this chapter, we describe our proposed economic framework, which combines insights gained through the literature review and site visits. Specifically, we provide information on the following:

- ▶ A modeling approach
- ▶ A characterization of the proposed economic framework.

Where relevant, we cite evidence from the literature and the site visits to substantiate choice of a given element. In Chapter 8.0, we provide a detailed mapping of the elements to the literature and findings from site visits.

7.1 Modeling Approach

There are two primary theories of technology adoption that arise from the traditions of sociology and economics. While both disciplines seek to explain adoption and diffusion of new technologies, they use different mechanisms to explain this behavior.

In theories from the sociology tradition, social networks have been found to influence technology diffusion in general, and physician behavior in particular. Studies have demonstrated the effect of peer networks on physician prescribing habits and adoption of evidence-based practices.⁷⁷⁰ However, medical technologies such as new prescription drugs or use of evidence-based guidelines differ significantly from EMRs in the type and amount of investment they require. The investment required to use new evidence-based guidelines is likely to be measured in physician labor hours. Physician time is valuable, and investing a modest number of hours to learn about use of a new prescription drug differs significantly from the substantial capital and time investments needed to explore and adopt complex technologies such as EMRs. Such substantial investments are therefore likely to be significantly influenced by costs and benefits or expectations of those costs and benefits. There is support from the literature and the site visits regarding the importance of costs and benefits to the investment decision.

Evidence from the current survey literature suggests that the most significant barrier to adoption is excessive financial costs in the face of uncertain benefits.^{771,772,773,774,775} Findings from the site visits corroborate the importance of costs and benefits to the adoption decision. The literature describes related factors that affect costs, benefits, and the uncertainty associated with EMR adoption.^{776,777,778} These include lack of information on costs and benefits, technical challenges associated with EMR adoption, and lack of product standardization. Information can play a significant role in reducing uncertainty.

Given the study objective of developing a microeconomic framework of EMR adoption, and the central role economic considerations play in the adoption decision, we have chosen to use economic models of technology diffusion as the basis for the framework. In addition to the costs and benefits, these models emphasize the role of information in influencing expectations of costs and benefits related to adoption of a new technology. Consequently, these models can be adapted to incorporate the role of social or peer networks as crucial channels of information that influence physician expectations of costs and benefits.

Having proposed to use models from the economics literature as the foundation of our framework (to be augmented by other disciplines), we now resolve the issue of micro versus macro models. Most of the macroeconomic models of technology diffusion describe

industrywide or economywide phenomena that specify aggregate functions that can be parameterized to yield S-shaped technology diffusion curves. In these models, the aggregate diffusion curves are not derived by aggregating individual adoption curves. One example of this class of macro-models of technology diffusion is the Bass epidemic model of diffusion (1969)⁷⁷⁹. Ford recently published a macroeconomic analysis of physician EMR adoption using a Bass model and projected that, at the current pace, complete market penetration would not occur until 2024.⁷⁸⁰

The challenge is that a macro-model not derived from underlying micro foundations of individual decision-making is less suited to a task in which we seek to understand and influence the behaviors of individual physicians. In addition, these models risk inaccurate estimation of relevant parameters and therefore of policy responses. It is therefore preferable to develop a framework that examines the microeconomic aspects of small practice adoption behavior that can be aggregated over all practices to obtain adoption curves for small practices. Microeconomic models of technology adoption allow for such a construct.

Microeconomic models focus on individual firm behavior and capture the influence of various factors and their impact on the firm's decision to adopt. More recent models of technology diffusion and adoption have been based on theories of investment under uncertainty.^{781,782} These models capture the role of uncertainty and expectations of costs and benefits in technology adoption, as well as the role information plays in reducing uncertainty.⁷⁸³ These models can be adapted to include factors such as cumulative learning or the impact of incremental knowledge accumulation. These models can be used to derive individual practice-level adoption curves that can be aggregated.

Given these considerations, we have chosen to model physician adoption behavior using a microeconomic approach. Specifically, our framework relies on models of options and investment under uncertainty⁷⁸⁴ that have been used extensively to study technology diffusion in economics.

7.2 Microeconomic Framework of EMR Adoption

In this section, we present the proposed economic framework of EMR adoption in small practice settings. For the purposes of this analysis, we define small practices as physician-owned practices of between one and nine physicians. The rationale for this classification is based on a number of considerations. With minor variations, existing surveys tend to classify physician practice sizes in the following way: 1, 2–4, 5–9, 10–20, or 10–50.^{785,786,787,788} Practices of 10 and over are therefore bucketed in a fashion that groups them with much larger practices. EMR adoption correlates strongly with practice size, and there appears to be a strong upward inflection in adoption in practices of 10 or more.^{789,790} Furthermore, by focusing on physician-owned practices of between one and nine physicians, we account for 76–88 percent of all physicians.^{791,792,793}

As noted above, we have also restricted the analysis to physician-owned practices, because physician ownership is strongly associated with a lower probability of adoption.⁷⁹⁴ Practices

owned by HMOs, hospitals, and other entities are much more likely to adopt, regardless of size. We presented these size and ownership parameters to members of our TEP, who concurred with this approach.

7.2.1 Specification of Framework Elements

The microeconomic model that we propose to capture physician adoption behavior includes the following key elements:

- ▶ Unit of decision-making
- ▶ Physician entity's objective function
- ▶ Characterization of technology
- ▶ Choice variables of physician entity
- ▶ Revenue function and uncertainty associated with EMRs' impact on revenue
- ▶ Costs associated with the practice and cost uncertainty associated with EMRs
- ▶ Existing stock of physician human capital and its impact on costs of adoption
- ▶ Role of information in reducing uncertainty associated with adoption.

In the rest of this section, we describe each of these elements in greater detail. Because we have chosen to use a microeconomic approach to modeling physician decisions, we need to specify the unit of decision-making and the objective function of the decision-making unit.

1. Unit of decision-making. We assume that the unit of decision-making is the physician entity. In the case of the solo practitioner, the entity and the individual coincide. We assume that multi-physician practices have a decision-making process that—for an outside observer—appears *as if* they possess a single decision maker or are more akin to a solo practice.

In this study, we are focused on the decisions of small practices in which the number of physicians range from one to nine. In the case of the solo practices, the decision-making unit is clearly the individual physician. In the case of a practice with multiple physicians, the physician may not be the decision maker, or there may not be a single decision maker. There may be a variety of ways through which decisions can be made. For example, in a larger practice, the decision maker may be the office manager (which may simplify the unit of decision-making to a single individual) rather than the physician. Even if the physicians make the decisions, there may be alternative mechanisms for making these decisions. In certain practices, decisions may be reached through democratic processes such as voting, while in others a dominant physician may play a crucial role in the decision-making. For example, if the majority of the ownership lies with a single physician, the decisions to adopt new technology may be determined by that physician.

The politics of decision-making within a multi-physician practice will certainly be affected by the distribution of ownership within the practice. In conducting our literature review, we were unable to find data that describe distribution of ownership within physician practices. Without data on distribution of ownership within a practice and its impact on decision-making, it is challenging to characterize who the decision maker would be in multi-physician practices. In addition, findings from the site visits did not suggest that the politics of decision-making had a

significant impact on the proclivity of a practice to adopt. Although a number of the office staff were involved in the decision to purchase an EMR, in the offices we visited, it was typically a single individual (usually a physician) who played a significant role in the selection of an EMR.

In the absence of such data, we chose this specification in order to maintain the focus on the economics rather than the internal processes of decision-making. Another rationale for proceeding in this manner is that policies to stimulate adoption such as incentives, subsidies, and provision of information are more likely to be targeted at the practice level rather than at individuals within that practice. We presented this specification of the unit of decision-making to members of the TEP, who concurred with this approach in the context of an economic framework.

Framework Element One: The unit of decision-making is a physician entity.

2. Physician entity's objective function. Having defined the physician entity as the decision-making unit, we now specify the objective function for this decision-making unit. We specify the objective for the physician entity as utility maximization, where the utility function is dependent on the following variables:

- ▶ Income
- ▶ Leisure
- ▶ Disutility from patient-related adverse events.

We specify the physician entity's utility function in the following manner:

$$U_i(Y_{it}(z), h_{it}(z)), e_{it}(z))$$

Where "i" represents the physician entity, "Y_{it}" represents the entity's income at time t, "h_{it}" is the leisure at time t, and "U_i(.)" is the utility associated with income, leisure, and the adverse patient outcome represented by e_{it}. The errors are affected by "z," which is the level of EMR functionality. We have described "z" in greater detail below. Utility increases with income and leisure and decreases with patient adverse events. The specification of this utility function takes into account physicians' preferences to provide quality care or "to first do no harm." Our choice of utility maximization as the objective function follows existing economic literature on modeling physician behavior in general, and on adoption of medical technologies in particular.^{795,796} In this literature, physicians maximize their utility functions by making choices between labor and leisure. Our site visits validated this specification.

Employing utility maximization as the objective function, as opposed to profit maximization, enables us to account for differences in risk preferences among physician entities. Differences in risk preferences among physician entities may play a significant role in adoption of EMRs. Mathematically, alternative parameterizations of the function U_i will yield varying levels of risk tolerance. The specification for the objective function presented here deviates from the classic industrial organization literature in economics, in which technology adoption is modeled as a decision made by a firm whose objective is to maximize profit. Under this specification, there is

no clear way to characterize firm preferences for risk. The underlying assumption is that each of these firms is atomistic, and ownership is diversified across multiple firms; therefore, risk preferences do not come into play. We therefore believe that utility maximization is a more apt conceptual framework to employ.

Framework Element Two: The physician entity maximizes utility that is a function of income, leisure, and adverse patient events.

$$U_i(Y_{it}(z), h_{it}(z), e_{it}(z))$$

The utility maximization problem specified here is an expected one. This is driven by the uncertainty surrounding the costs and benefits of adopting the EMR technology “z.” We specify z and the uncertainty around costs and benefits below.

3. Characteristics of EMR technology

Rather than restrict the technology to a single definition of EMR, we chose to represent the diversity of technologies available and permit the physician entity to make a choice about which specific type of EMR technology it wants to adopt. We use “z” to represent the EMR technology, and z can assume a series of discrete values: z_1, \dots, z_n that are associated with varying types of EMR functionality. In addition, we specify “ z_{i0} ” to represent the *incumbent* technology (e.g., paper-based charting) used by entity i. In each period, the choice is between using the incumbent technology or adoption of a given z where z belongs to z_1, \dots, z_n . The specification of the technology here is similar to the quality ladders described in models of Grossman and Helpman (1991).⁷⁹⁷ The technology z can be represented as a ladder, with higher rungs of the ladder representing higher levels of functionality. The decision for the physician entity is to determine which rung of the ladder, or value of z, to choose.

This characterization of EMR technology was informed by the literature and the site visits. As discussed in Section 4.2 of the literature review, there are a number of alternative definitions and functional models of EMR. The functionalities associated with an EMR may vary from simple viewing capability to the much more advanced functionality described in Generation V of the Gartner model.⁷⁹⁸ The site visits reinforced this concept of a continuum of technologies. Although practices visited had adopted similar functions such as scheduling, documentation, order entry, patient history, and report generation, there was significant variation both in sophistication and customization of these capabilities. The choice for the physician entity is therefore not about “one” technology, but rather a variety of EMR technologies, each associated with a certain degree of functionality.

Finally, there is insufficient data in the public domain to associate each value of “z” with a specific combination of EMR functionalities. Specification of an EMR that could be associated with a particular value of “z” would require empiric estimates based on a large survey. The data would need to capture clusters of EMR functionality adopted by physicians. In the absence of such data, the TEP concurred with our existing specification.

Framework Element Three: The EMR technology z can assume a series of discrete values where higher levels of z represent higher levels of functionality.

4. Choice variables of physician entity. Having specified the objective function for the physician entity and the technology z , we describe the variables that the physician entity chooses to maximize its objective function. The choice variables that maximize the physician entity's utility function in each time period are physician's labor l_i for providing patient care, time spent on researching EMRs b_i , technology " z ," and other inputs x_i . The physician entity's choice of labor is constrained. We normalize the time input to one, and in each time period, the choice of labor l_{it} must satisfy the following constraint:

$$l_{it} + b_{it} + h_{it} \leq 1$$

These other inputs x_{it} could refer to other types of labor used in a physician practice such as nurses, physician assistants, and office managers. This specification of choice variables follows literature published by Reinhardt and Thurston,^{799,800} as does the measure of output R_{it} , and these have been validated by the data collected from the site visits. At each of the sites, physicians use a combination of their time and inputs from other types of labor to provide patient care and generate revenue. In addition, the literature and the site visits validate the use of a revenue function R_{it} . The specification of b_i is based on findings from the site visits, which revealed the time spent by physicians on researching EMR vendors and functionalities.

The physician entity's choice of inputs and technology z produces revenue for the practice, which is given by the following equation:

$$R_{it} = f(l_{it}, z, x_{it}) + \epsilon_{it}(z)$$

where R_{it} represents per-period revenue for entity i which is a function of physician labor l_{it} , technology z , and other inputs x_{it} , and $\epsilon_{it}(z)$ is random and drawn from a distribution function G_{it} . We assume that $\epsilon_{it}(z)$ equals zero at z_0 .

We have chosen to specify a general revenue function to account for a given entity's alternative reimbursement mechanisms. These could, for example, include fee-for-service (FFS) or capitation. While the EMR technology has shown the potential to increase revenue and charge capture, there is uncertainty around the realization of these benefits. We characterize this uncertainty using a Bayesian formulation.

We assume that the distribution function G_{it} is characterized by a single parameter θ . Given the uncertainty physicians encounter in adoption of the new EMR technology, they lack information on the parameters of the distribution function G_{it} , namely θ . There is a crucial difference between the physician entity's lack of knowledge about the parameters of G_{it} and the risk that the same entity faces when placing bets in a coin-flip. In the case of a coin-flip, the physician entity knows

the odds and the probability associated with a given outcome. In the case of EMR adoption, the entity does not know the probability associated with specific outcomes post-implementation. Specifically, physicians do not know θ (i.e., θ is itself random).

Based on the information a physician entity has at the start of each time period, it has a prior distribution function K for Θ , the random variable associated with θ . Let us assume that K is a beta distribution with parameters α and β . We chose this functional form because it allows us to explicitly compute the posterior distribution function if the practice collects more information. The physician entity then samples “ n ” practices that are similar to theirs and have adopted EMR technology. We will assume that δ percent of practices show favorable results. The posterior distribution K' is also a beta distribution with parameters $(\alpha + n*\delta)$ and $(\beta + n*(1 - \delta))$. As n approaches infinity, the expected value of Θ (the random variable) with the K' distribution approaches true value of θ , and the variance approaches zero. Intuitively, the physician entity learns enough about the true value of θ if it is willing to chose a sufficiently large sample size. The sample size “ n ” is a function of the amount of time that a physician entity chooses to spend in sampling adopters. Specifically—

$$n = g(b_{it})$$

This specification also underscores the importance of peer group effects, which is emphasized in the social network theories of adoption and was certainly an important factor in the EMR decision-making process for the sites.

Framework Elements Three and Four: The physician entity chooses labor (to provide patient care and research EMRs), other inputs x , and technology z to maximize utility. Certain benefits that arise from adopting EMRs such as enhanced charge capture, improved coding, reduction in day’s receivables, and the associated uncertainty are captured through the revenue function. The expectations of these benefits are updated in each time period using a Bayesian approach.

5. Costs Associated with Technology. The costs accrued by the physician entity in each time period are given by the cost function $C(\cdot)$. The cost function is given by—

$$C_{it} = w_{it}l_{it} + r_{it}x_{it} + s_{it}(z) + I_{it}(z, \mu_i) + v_{it}(z, \mu_i) + p_{it}(z) + F + \eta_{it}(z),$$

where—

- ▶ $w_{it}l_{it}$ is physician labor costs (w_{it} is physician wages)
- ▶ $r_{it}x_{it}$ are the costs associated with non-physician labor
- ▶ s_{it} represent non-labor recurring costs such as stationery costs
- ▶ $I_{it}(z)$ are the investment and other costs associated with adoption of z (this includes hardware and software, training and other one-time implementation costs, selection costs, and costs of borrowing)

- ▶ $v_{it}(z)$ represents the recurring costs of the technology “z”
- ▶ μ_i is the stock of the physician entity’s human capital that can help lower the costs of adoption
- ▶ $p_{it}(z)$ represents costs associated with treating patients—these could be impacted and can result in a benefit to the physician under a capitated environment
- ▶ F is the fixed cost of operating the practice, such as rent
- ▶ $\eta_{it}(z)$ captures the uncertain effect of z on costs.

We assume $\eta_{it}(z)$ equals zero at z_0 . Existing literature has shown that adoption of EMRs can have an effect on practice costs, such as reductions in labor costs. The cost function incorporates the various categories of costs reported in the literature and confirmed through our site visits.^{801,802} Site visits yielded additional insights into a key factor that may impact the acquisition and implementation costs: a physician entity’s previously accumulated human capital. This factor can be acquired through prior experience with EMRs (e.g., through residency) or through education in disciplines such as electrical engineering. We assumed that $I_{it}(\cdot)$ and $v_{it}(\cdot)$ are decreasing in μ_i .

Physicians are uncertain about the effects of z on costs and form expectations about them in each time period. The arrival of new information changes those expectations. We assume that $\eta_{it}(z)$ is random and is distributed H_{it} with underlying parameter γ . Existing literature has shown that adoption of EMRs can have an effect on costs related to a practice such as reductions in labor costs. Physician entities are, however, uncertain about the effects that the EMR technology z has on costs. Although γ is unknown, the physician entity has a prior distribution M for Γ , the random variable associated with the parameter γ . We assume that M is a beta distribution with parameters ϕ and λ . The posterior distribution M' is also a beta distribution with parameters $(\phi + n*\sigma)$ and $(\lambda + n*(1 - \sigma))$, where σ is the percent of practices that show favorable results, and n represents the number of adopters the physician entity samples. This number “ n ” is a function of the amount of time that a physician entity chooses to spend, as well as the financial cost associated with that sampling process.

Framework Element Five: The costs associated with a technology consist of variable costs, fixed costs associated with inputs, and the costs of investing in technology z . These practice costs can be affected by the adoption of the technology z , although the impact is uncertain and random. Practice entities update their priors about the impact of the technology z on costs in a Bayesian manner.

Finally, we specify the relationship between income Y (which enters the utility function), revenue R , and costs C as follows:

$$Y_{it} = R_{it}(\cdot) - C_{it}(\cdot)$$

The survey literature has shown that there are certain factors that correlate with adoption; namely, age, specialty, location, ownership, and practice size.^{803,804} These factors are, to a

certain extent, implicit in the model. Age can be incorporated using a finite time horizon. It is unclear if the practice entity's age is tied to the physicians' ages, or if they behave more like infinitely-lived firms. There was no data either from the literature review or from the site visits to provide insights into this issue.

Specialty and location are captured through the subscript “*i*” since that denotes a specific type of entity. The subscript “*i*” defines a unique utility, revenue, cost, and random distributions for a specialty and location. The survey literature has shown that specialty and location are correlated with adoption.^{805,806} Specialty and location may impact adoption, since there may be surrogates for other factors. For example, location could capture effects of the following factors: reimbursement rates, dominance of single payor, and presence of standards or local health information networks, all of which can affect the cost and revenue functions of the practice. Specialty can also affect adoption through its impact on the costs and revenues, since reimbursement rates differ among specialties as well as information needs (which can impact costs of the technology adopted).

7.3 Conclusion

We have proposed an economic framework that focuses on the physician entity's decision to adopt an EMR. Our framework incorporated aspects from social network theory into models from economics. The goal is to understand what factors affect adoption and where “glitches” exist. Glitches include barriers such as lack of access to capital and a lack of easily acquired, reliable information on the benefits and costs associated with an EMR. Gaining an understanding of what hinders adoption can be useful for designing policy and program interventions that can foster adoption.

8.0 Mapping of Framework for EMR Adoption

8.1 Introduction

The development of our proposed economic framework and its associated elements were informed by a review and analysis of the literature on EMR adoption and data gathered from site visits. The underlying construct for our framework was based on using models of technology diffusion from economics combined with elements from social network theory. We used this construct to integrate key variables from the literature that have been shown to be relevant to adoption. As described in Chapter 7.0 the proposed economic framework had the following major elements:

- ▶ Unit of decision-making
- ▶ Physician entity's objective function
- ▶ Characterization of technology
- ▶ Choice variables of physician entity
- ▶ Revenue function and uncertainty associated with EMRs' impact on revenue
- ▶ Costs associated with the practice and cost uncertainty associated with EMRs
- ▶ Existing stock of physician human capital and its impact on costs of adoption
- ▶ Role of information in reducing uncertainty associated with adoption.

In this chapter, we provide a discussion of the mapping or relationship between these elements from the economic framework to the variables identified in the literature and the data gathered from site visits that are relevant to EMR adoption. Our discussion is organized as follows: we briefly describe each element from the proposed framework and then map each element to the literature and/or the site visits.

8.2 Mapping of Proposed Economic Framework

8.2.1 Unit of decision-making

The first element of the proposed economic framework is the unit of decision-making. In the framework we specified the unit of decision-making as the physician entity. In the case of solo practices the physician entity is the individual physician, while in a group practice, we assumed that the decision-making process for an outside observer would appear as if it were performed by a single physician similar to a solo practice. We have therefore chosen to abstract from the internal decision-making processes of individual practices and assume that multi-physician practices for the purposes of the framework act as if there were a single decision-maker.

Our decision to represent the unit of decision-making as a physician entity relies significantly on the seminal work of Uwe Reinhardt.⁸⁰⁷ In his 1970 paper, Reinhardt developed a model that analyzed the production function of physician services. The unit of analysis in his study was the office-based physician practice. The physician practice chooses various inputs (labor and capital) to produce output of physician services. While in a multi-physician practice there may be a

variety of decision-making processes that can result in an observed hiring of specific inputs, Reinhardt chose to abstract from these decision-making processes. The choice of input levels, even in a multi-physician practice is modeled as if there were a single physician. This approach in representing the unit of analysis is standard in the health economics literature and has subsequently been applied in other studies.⁸⁰⁸

The survey literature also does not examine the internal decision-making processes of organizations in relation to EMR adoption.^{809,810,811} They focus on a number of observable factors such as size, specialty, location, and means of compensation. It is conceivable that internal decision-making processes can affect adoption rates; however, the survey literature has shown that the factors significantly associated with adoption are high investment costs in the face of uncertain benefits. Given this emphasis in the survey literature and the specifications used in the healthcare economics literature, we have chosen to represent the decision-making unit as the physician entity.

In addition to the evidence from the literature the data gathered from the site visits also supports the specification. In all the sites that we either visited or interviewed the decision to research and adopt EMRs was led a single physician. The other physicians and staff in the office provided input and participated in the EMR decision-making process. However, the internal politics of the decision-making were not critical factors in the adoption decision. The offices appeared to function seamlessly as if there were a single physician. Based on the evidence from the literature and the site visits we specify that the unit of decision-making is the physician entity.

8.2.2 Physician Entity's Objective Function

The second major element in the framework was the physician entity's objective function. The entity was assumed to maximize a utility function that was specified as follows:

$$U_i((Y_{it}(z), h_{it}(z)), e_{it}(z))$$

where 'i' represents the physician entity, Y_{it} represents the i th entity's income at time t , ' h_{it} ' is the leisure at time t , $U_i(\cdot)$ is the utility associated with income, leisure, and adverse patient outcome e_{it} , and ' z ' is the EMR technology.

We considered two candidate specifications of the objective functions prior to adopting the utility maximization. The first specification, based upon standard microeconomic theory of the firm, would treat physicians like firms whose objective is to maximize profit. There are a couple of factors relevant to the physician practice that renders profit maximization inapplicable to a physician practice. The first factor is that in addition to income or profit, physicians seem to care about non-financial attributes such as patient safety or quality. The survey literature has shown that one of the motivators of physician adoption of EMR is its potential to improve patient safety and quality.⁸¹² The second factor that is implicit in the profit maximization assumption is that firms do not have different preferences for risks. There is therefore, there is no clear way to characterize firm preferences for risk under this specification. The underlying assumption is that each of these firms is atomistic and ownership is diversified across multiple firms, therefore risk preferences do not come into play. The survey literature has shown that one of the significant

barriers associated with EMR adoption is the uncertainty associated with the new technology and the various ways that practices deal with this uncertainty.^{813,814} These differences in the way practices view uncertainty can explain the 15-18 percent adoption rate even among small practices.^{815,816} This would imply that practices have different preferences for risk and any practice level objective function needs to be able to capture these preferences for risk. In addition, our specification of the utility maximizing objective function coincides with the seminal work of Reinhardt in which he specifies utility maximization as the objective of the physician practice.⁸¹⁷

The specification we have adopted has two features. First, alternative specifications of the utility function can yield alternative risk preferences: risk aversion, risk neutrality, or risk loving. In addition, the subscript 'i' refers to the ith entity's utility function. This subscript represents a way to capture some of the practice entity specific characteristics that in the survey literature have been shown to be relevant to adoption – specifically specialty.^{818,819,820} In the Discussion of the Literature chapter we hypothesized various ways in which specialty can affect adoption of EMRs. Specifically in chapter 5.4.3 we discussed the potential correlation between specialty and appetite for risk. Using a subscript 'i' for the utility function provides us with the ability to develop alternative risk specifications that could be associated with different specialties.

The second feature, in addition to the assumption of practice entity utility maximization, we also specified as shown in the equation above the arguments of this utility function. The arguments in this utility function are income, leisure, and patient outcomes. The current specification implies that these three variables are what physicians care about. All of these arguments can be affected by the type of EMR technology adopted, represented by 'z'. In specifying the arguments of the utility functions we relied once again on the survey literature as well as common representations used in health economics.

In chapter 5.4.3 of the Discussion of the Literature chapter we discussed several benefits and barriers that promote or deter EMR adoption. The survey literature provides evidence that these perceived benefits and barriers are important motivators of EMR adoption. The survey literature has shown that physicians want to adopt EMRs because they expect the new technology to either increase their revenue or reduce their costs, both of which lead to increases in the physician entity's income. This would suggest that physicians care about income, justifying the inclusion of this argument in the utility function. In addition to income, our specification includes leisure as one of the arguments in the utility function. The survey literature and the Davies awards highlight the importance of workflow efficiencies of EMR adoption including efficiencies related to refills, scheduling, and telephone communications. All of these efficiencies expected or realized may, in addition to yielding financial benefits, lead to increases in physician and staff leisure time. We have therefore included leisure as a variable in the utility function to capture the potential impact of EMR induced workflow efficiencies on leisure. This leisure variable can also be viewed as a surrogate for expected benefits related to EMR adoption that relate to improvements in staff satisfaction.

In addition to income and leisure, physicians have stated that the potential quality and safety benefits of EMRs also serve as important motivators of adoption. This would imply that in

addition to income, physicians care about patient outcomes. We have chosen to represent this aspect through the $e_{it}(z)$, which represents the utility that physicians receive from patient outcomes and the ability of ‘z’ to affect these outcomes. The argument $e_{it}(z)$ can yield disutility caused by adverse patient outcomes.

The data gathered from the site visits supported the specification of this element. All of the sites we interviewed were for-profit practices implying that physicians care about income and as a practice one of their objectives is to maximize net income or profit. Physicians who had adopted EMRs reported the positive impact of EMRs on their leisure time. In addition to the preferences over income and leisure, all the adopter sites we interviewed stated that they viewed EMRs as critical to promoting quality and safety. This appeared to be one of the key motivators for adoption for certain sites. This implies that physicians have preferences over quality and care about providing safe and effective care that is free of medical errors to their patients.

We summarize the relationship between variables found in the literature to be relevant to EMR adoption and the physician entity’s utility function in Exhibit 37 below.

Exhibit 37. Framework Elements Related to the Physician Entity’s Utility Function

Framework elements	Factors Relevant to Framework	Evidence from Literature	Evidence from Site Visits
$U_i(Y_{it}(z), h_{it}(z), .)$	Increased Physician Profit	Davies Awards ^{821,822,823,824,825,826,827,828,829,830} Gans ⁸³¹	Sites A,B,C, D,E and F
	Improved charge capture		
	Decreased Charting Time		
	Improved practice efficiency		
	Decrease in costs		
	Uncertainty of benefits		
$U_i(Y_{it}(z), h_{it}(z), e_{it}(z))$	Improved Decision Making	Audet et al. ⁸³² , Gans ⁸³³ , MRI ⁸³⁴ , Miller and Sim ⁸³⁵ Davies Awards ^{836,837,838,839,840,841,842,843,844,845}	Sites A,B,C, D,E and F
	Improved access to information		
	Reduce Medical Errors		
	Improved Adherence to Clinical Guidelines		
	Improved Legibility and Data Capture		
	Improved Patient Safety		
	Improved Clinical Decision Support		
	Increased Information Sharing		
	Increased Immunization Rates		

8.2.3 Characteristics of Technology

In our preliminary framework we specified the EMR technology as a set of discrete values that are associated with various levels of EMR. We represented these discrete functionalities as follows: z_1, \dots, z_n . Each value of z is associated with a specific EMR functionality. There is no

direct and obvious mapping between our specification of z in the preliminary framework and the literature that defines EMRs. In reviewing this literature we encountered a number of different ways that EMR is defined from organizations such as the Institute of Medicine, Health Level 7, and Gartner. There is also a description of various EMR functionalities that physicians have adopted as described in Gans. While there are differences among these models, they all share certain common features; there are varying levels of EMR functionality from systems that include very simple functions to ones that include complex levels of functionality. The higher levels of functionality may be associated with higher levels of costs and benefits.

The data gathered from the five sites that had adopted an EMR were not yield definitive evidence related to characterizations of z . Although the five sites that had implemented systems that shared some common functionalities including structured documentation, results viewing, medication and test ordering, there were also differences with the level of functionality. There were differences with user interfaces, variations based on the physician specialty, and connectivity with laboratories or pharmacies. Given these differences, one would need a larger data set to identify clusters of EMR functionality that can be used to more accurately characterize z . The TEP recommended that it would be preferable to gather data from a large sample of physicians and use statistical techniques such as cluster analysis to help define ‘ z ’.

We have therefore chosen to specify z as a technology ladder similar to that used by Grossman and Helpman (1991).⁸⁴⁶

8.2.4 Choice Variables of Physician Entity

The next element of our framework refers to the physician entity’s choice variables. The choice variables that maximize the physician entity’s utility function are physician’s labor l_{it} or alternatively leisure, time spent on researching EMRs b_{it} , technology ‘ z ’, and other inputs x_{it} . All the sites that had adopted an EMR, had researched EMRs for several weeks prior to adoption. We therefore used b_{it} to denote the time that a physician chooses to devote to EMR research. Decisions related to choice of ‘ z ’ represent the practice entity’s EMR adoption decision. This specification of the choice variables follows Reinhardt and Thurston.^{847,848} The inputs x_{it} is a vector that refers to non-physician labor inputs such as labor of registered nurses, physician assistants, office managers, as well as non-labor inputs such as paper and office space. The choice variables represented here are standard and are also based on our knowledge of the inputs used in a physician office to produce services.

8.2.5 Revenue Function and Uncertainty Associated with EMRs Impact on Revenue

In our updated economic framework, the physician entity chooses the various inputs to produce revenue. The relationship between the physician entity’s revenue and the choice of inputs is given by the following equation:

$$R_{it} = f_i(l_{it}, z, x_{it}) + \varepsilon_{it}(z)$$

where R_{it} represents per period revenue for entity i which is a function of physician labor l_{it} , technology z , and other inputs x_{it} , and $\epsilon_{it}(z)$ is random and drawn from a distribution function G_{it} and is meant to capture the uncertainty associated with the realization of benefits cited in the literature.

Our specification of the revenue function is similar to the one used by Reinhardt. In his paper he used a production function, in which different physician and non-physician inputs were combined to produce output of physician services. Rather than use output, we have chosen to use revenue since the physician entity's revenue is determined by the output and the price of services. Any technology that affects the quantity of output as well as its unit price can change revenue. Given the complexity of the healthcare market and its associated reimbursement mechanisms we have chosen at this stage to represent a generalized revenue function that has the ability to capture multiple reimbursement mechanisms. The site visits revealed that although a majority of sites were reimbursed on a fee-for-service (FFS) basis, there was at least one site that received capitated payments.

The survey literature and Davies awards have highlighted certain perceived or actual benefits physicians have realized or expect to realize as a result of EMR adoption that either changes the unit price that physicians receive for a given service or changes the volume of services rendered. These impacts relate directly to the ability of EMRs to increase revenue through a variety of means including improved charge capture, improved coding, and increased patient volumes.

The data gathered from the site visits coincided with the findings from the literature. All the practice sites that had implemented an EMR reported benefits from improved coding, quality of documentation, and charge capture. This implies that for a given visit the practice is likely to experience increased revenues from EMR adoption. None of the practices were able to quantify the increases in revenue from EMR adoption. Despite this inability to quantify the benefits there is still evidence from the literature and these sites that improvements in revenue can occur through EMR adoption.

We present the list of specific benefits (actual or expected) related to adoption that have been identified in the literature that we have related to potential increases in the revenue. The function f captures the relationship between these expected benefits from z and revenue.

Exhibit 38. Framework Elements Related to Revenue

Updated Framework Elements	Factors Relevant to Framework	Evidence from Literature	Evidence from Literature
$R_{it} = f_i (I_{it}, z, x_{it})$ Potential impact : Revenue Enhancement through increases in unit price	Improve Charge Capture	Wang ⁸⁴⁹ , Miller ⁸⁵⁰ , Medical Records Institute ⁸⁵¹ , Davies Awards ^{852,853,854,855,856,857,858,859,860,861}	Sites A-F
	Improve Charge Quality with Documentation		
	Improved Collection Rate		
	Increased coding levels		
	Decreased Denials due to Coding Errors		
Revenue enhancement due to factors that can increase patient volume $R_{it} = f_i (I_{it}, z, x_{it})$	Improved Overall Workflow Efficiency	Davies Awards ^{862,863,864,865,866,867,868,869,870,871} Gans ⁸⁷² , Wang ⁸⁷³ , Miller ⁸⁷⁴ , Medical Records Institute ⁸⁷⁵	Site B, D, G
	Improved Drug Refills Capabilities		
	Eliminate/Reduce Chart Pull: Instant access to Chart		
	Decreased Charting Time		
	Patient Scheduling Efficiencies		
	Decrease Insurance Turnaround Time		
	Decrease phone call turnaround time		
	Increased attention/ improved customer service		
	Decrease patient wait time		
	Improved practice efficiency		
	Improved employee retention		
	Increase time with patient		
	Expanded Office Space Creating a Competitive Advantage		

The first set of factors show the impact that adoption of an EMR can have on the unit price of a service. These sets of factors lead to an increase in revenue through improvements in charge capture and coding for the same types of services rendered by the physicians. The second set of

factors shows potential enhancements to revenue through increases in patient volume. Patient volume can increase based on the ability of the practice to see new patients due to improved workflow efficiencies generated by EMRs. In addition to providing more time for physicians to see new patients, workflow and other practice efficiencies can enhance practice reputation and patient experience creating competitive advantage that can lead to higher patient volume.

Five of the eight sites reported a variety of improved efficiencies and benefits listed in the Exhibit above. One site reported converting a billing office into additional patient examination rooms. Another site expected existing rooms used to store charts to be converted into exam rooms upon implementation. It would be reasonable to expect that with improved efficiencies practices may be able to increase their revenue by attracting more patients. None of the practices we interviewed however reported increases in patient volume. None of the practices (except Site G) reported a competitive advantage due to EMR adoption. As the sites did not quantify any of these benefits we are unable to determine what the true impact on revenue. It does appear that with some of the improved efficiencies may lead to increases in revenue through increases in patient volume.

In addition to the factors described above, there are other factors that may affect the unit price and therefore the revenue that a practice receives. These include specialty and location. In Chapter 5.4.1 of the Discussion of the Literature document, we hypothesized that one of the reasons that these variables can affect EMR adoption is because they impact reimbursement (unit price) thereby affecting revenues. We have used the subscript 'i' to represent these reimbursement aspects ties to specialty and allocation.

Finally, one of the key aspects of the revenue function is that it is random. The random nature of the revenue function is determined by the uncertainty associated with EMRs to generate specific types of benefits. We can specifically map the random variable $\epsilon_{it}(z)$ to the following two findings from the literature:

- ▶ Lack of clear evidence on the ability of EMRs to generate workflow efficiencies – In Chapter 4.3 we analyzed the literature on EMRs and efficiency and concluded that it sent mixed messages to physicians. This can cause physicians to feel uncertain about the potential for EMRs to generate benefits.
- ▶ Direct evidence from the survey literature – One of the dominant themes that has emerged from the survey literature is the uncertainty that physicians' have directly expressed about the ability of EMRs to generate benefits. High costs in the face of uncertain benefits are a major factor that has been found to be a barrier to adoption.

It is therefore important for this preliminary framework to capture the above two pieces of evidence from the literature. We have incorporated uncertainty in realization of benefits through use of $\epsilon_{it}(z)$. We also specified the distribution function G_{it} from which $\epsilon_{it}(z)$ is drawn from. The function G_{it} is specific to each physician entity and also changes with time, i.e. each physician entity at the start of each time period has a prior about the distribution of benefits associated with adoption of EMRs. This prior is updated each time period using a Bayesian

approach based on the information received by the entity in that time period. In our framework the updating of G_{it} in each time period captures the role that information can play in the adoption decision. While the survey literature highlights the importance of benefit uncertainty in EMR adoption, physicians did not explicitly ask for improved information on EMR benefits. The Gans survey however, did uncover evidence that physicians were seeking information on information that would help them select an EMR.

It is conceivable that reliable information on the benefits of EMRs will also help reduce uncertainty around the benefits and promote adoption.

The importance of information in adoption of new technologies is explicitly emphasized in the technology literature from economics. In addition, the literature on social networks and Rogers theories of diffusion stress the importance of peer networks in the adoption decision. One of the major ways in which peer networks can influence adoption is through supply of information.

8.2.6 Costs Associated with Technology

The final element in the framework is the costs associated with adoption. We specified the cost function as follows:

$$C_{it} = w_{it}l_{it} + r_{it}x_{it} + s_{it}(z) + I_{it}(z, \mu_i) + v_{it}(z, \mu_i) + p_{it}(z) + F + \eta_{it}(z),$$

where:

- ▶ $w_{it}l_{it}$ is physician labor costs (w_{it} is physician wages)
- ▶ $r_{it}x_{it}$ are the costs associated with non-physician labor
- ▶ s_{it} represent non-labor recurring costs such as stationery costs
- ▶ $I_{it}(z)$ are the investment and other costs associated with adoption of z (this includes hardware and software, training and other one-time implementation costs, and costs of borrowing)
- ▶ $v_{it}(z)$ represents the recurring costs of the technology ‘ z ’
- ▶ μ_i is the stock of the physician entity’s human capital that can help lower the costs of adoption
- ▶ $p_{it}(z)$ represents costs associated with treating patients – these could be impacted and can result in a benefit to the physician under a capitated environment
- ▶ F is the fixed cost of operating the practice such as rent, and
- ▶ $\eta_{it}(z)$ captures the uncertain effect of z on costs.

Our specification of the cost function relies on the variables identified in the cost-benefit and survey literature, the Davies awards, and the data gathered from the site visits. Some of these can be readily recognized as cost variables while others that may not appear to be are in fact related to costs. Exhibit 39 below summarizes the variables from the literature and the site visits that map to the cost function specified in the updated framework.

Exhibit 39. Framework Elements Related to the Cost Function

Updated Framework variables	Cost variables relevant to framework	Evidence from literature	Evidence from Site Visits
$I_{it}(Z)$ includes costs to evaluate and acquire an EHR	Hardware	Wang ⁸⁷⁶ , Miller ⁸⁷⁷ , AAFP Vendor Survey ⁸⁷⁸ , Gans, 2005 ⁸⁷⁹	All sites
	Software	Wang ⁸⁸⁰ , AAFP Vendor Survey ⁸⁸¹	All sites
	Software training and installation	AAFP Vendor Survey ⁸⁸² , Miller, 2004 ⁸⁸³	All sites
	Workflow redesign	Wang ⁸⁸⁴	
	Training, e.g. use of software	Wang ⁸⁸⁵	All sites
	Creating a migration plan	Medical Records Institute ⁸⁸⁶	
	Other implementation costs	Miller ⁸⁸⁷ , AAFP Vendor Survey ⁸⁸⁸	All sites
	Paper-electronic chart conversion	Wang ⁸⁸⁹	All sites
	Productivity loss during implementation	Miller ⁸⁹⁰ , Gans ⁸⁹¹ , AAFP Vendor Survey ⁸⁹²	All sites
	Technical/System support	Wang ⁸⁹³ , AAFP Vendor Survey ⁸⁹⁴	All sites
	Complex contracts	AAFP Vendor Survey ⁸⁹⁵	Site B, F, H
	Inability or challenges in evaluating, comparing, and selecting an EHR	Gans ⁸⁹⁶ , AAFP Vendor Survey ⁸⁹⁷ , Medical Records Institute ⁸⁹⁸ , Miller and Sim ⁸⁹⁹	Site B, E, H
	Lack of Observability or Trialability (Lack of having Previously Used or tried an EHR) Technical Ability to Use	Rogers ⁹⁰⁰ , Bower ⁹⁰¹	Not cited
$v_{it}(z)$ – recurring costs associated with EHRs	Software maintenance and support	Miller ⁹⁰²	All sites
	Hardware replacement	Miller ⁹⁰³	All sites
	Internal IS/external IS contractors	Miller ⁹⁰⁴	Sites C and H
	Other ongoing costs e.g. cumbersome data entry	Miller ⁹⁰⁵	Site A
$W_{it}I_{it}$ – physician labor costs	While this is an important cost category any impact on these costs due to EMR adoption is obtained through improved practice efficiency	No source	All sites
$r_{it}X_{it}$	Personnel savings (excl. transcription savings) e.g. FTE for office support Reduced chart staff Improved employee retention	Miller ⁹⁰⁶ , Pediatrics at the Basin ⁹⁰⁷ , Sports Med & Orthopedic Specialists ⁹⁰⁸ , Southeast Texas Medical Associates ⁹⁰⁹	Site A, E

Updated Framework variables	Cost variables relevant to framework	Evidence from literature	Evidence from Site Visits
S_{it}	Chart pull savings Transcription savings Paper supply savings Savings in chart handling Reduced costs for handling telephone calls	Southeast Texas Medical Associates ⁹¹⁰ , Wang ⁹¹¹ , Miller ⁹¹² , RiverPoint Pediatrics ⁹¹³ , Pediatrics at the Basin ⁹¹⁴ , North Fulton Family Medicine ⁹¹⁵	Site G,F,E, D
μ_i	Existing Stock of human capital relevant for EMR adoption	None found	Sites B, E,G,F
$P_{it}(z)$	Drug savings Reduced radiology use Reduced laboratory use Drug utilization Decreased lab results reporting	Wang ⁹¹⁶ , Johnston, 2003 ⁹¹⁷ , Davies Awards ^{918,919,920,921,922,923,924,925,926,927}	Not cited
F	Eliminated chart storage room	Davies Awards ^{928,929,930,931,932,933,934,935,936,937}	Sites A-F
$\eta_{it}(z)$ – captures uncertainty associated with costs	<ul style="list-style-type: none"> • Variability in ability to negotiate prices with vendors • Uncertainty over appropriate levels of functionality and therefore of associated costs • Lack of adequate information on costs incurred to research and evaluate an EMR • Lack of uniform standards • Obsolescence & Trust: Risk of vendor going out of business • Inability to evaluate, compare, and select an EMR • Lack of structured medical terminologies • System Understanding: Solutions are Fragmented, Solutions Do Not Meet Requirements, Inability to Evaluate and Select EMR, Inherent Complexity of EMR • Lack of Evidence of Effectiveness 	Miller ⁹³⁸ , Gans ⁹³⁹ , Audet ⁹⁴⁰ , AAFP ⁹⁴¹ , Medical Records Institute ⁹⁴² , Miller and Sim ⁹⁴³	

Similar to the specification of uncertainty in, the random variable $\eta_{it}(z)$ is distributed to capture a physician entity's expectations about uncertainty. In a way similar to the revenue side the arrival of new information in each time period will lead to Bayesian updating of H_{it} . The Gans survey uncovered evidence on the types of information that physicians are seeking:

- ▶ Development of standardized questions to ask EMR vendors

- ▶ Model requests for proposal for EMR and models for contracts
- ▶ Educational programs on how to select and implement an EMR
- ▶ Certification of EMR vendors
- ▶ Integration capabilities of EMR products with various practice management systems.⁹⁴⁴

In addition to the Gans survey, data from the sites indicate uncertainty as a factor relevant to EMR adoption. Although uncertainty was not explicitly cited by the various sites, similar to the literature specific remarks made by the sites imply that uncertainty is an issue. Among the relevant factors cited include:

- ▶ Having reasonable expectations about performance which can have an impact on costs
- ▶ Concerns about vendor stability
- ▶ Investment irreversibility
- ▶ Anticipation of hidden costs that are not provided under contracted price
- ▶ Many implementation challenges including those related to conversion of paper charts

8.3 Conclusion

In this chapter we have provided an updated mapping of the variables in our framework to the evidence from the literature and data gathered from our site visits. For many of the variables there is concordance between the literature and the site visit data. Additionally, the site visits provided insights into variables that also appear to be relevant for adoption.

9.0 Approach to Validation of Proposed Framework

9.1 Introduction

The proposed economic framework uses a microeconomic approach to describe the variables relevant to the adoption of EMRs by physicians in small practice settings. These variables were drawn from a review of the literature and visits to eight small practices. The construct used to synthesize these variables was based on microeconomic models of technology diffusion combined with elements from social network theory. The framework represents a high-level theoretical specification of the variables relevant to adoption and their interrelationships. For the framework to be useful from a policy perspective, it will be necessary to validate it and test its ability to explain and possibly predict adoption rates among small practices. To validate the framework and understand the quantitative effect specific variables have on adoption, it will be necessary to obtain data at the small practice level. In reviewing relevant literature, we did not find any data sources in the public domain that can be used to validate the framework. In this chapter, we describe a methodology to further refine and validate the proposed economic framework.

9.2 Validating the Framework

Although the proposed economic framework appears simple, actual computation and validation of this framework involves solving a fairly complex multi-period nonlinear optimization problem. The framework validation process involves three major phases:

- ▶ *Phase I:* Evolution of the framework into a model through detailed mathematical specification
- ▶ *Phase II:* Collection of data that can be used to validate the model
- ▶ *Phase III:* Model estimation and validation.

In the following sections, we describe each of these phases in detail.

9.2.1 Phase I: Development of Economic Model

Although the current framework contains all of the major elements that EMR adoption literature has shown to be relevant to adoption, the framework is not in a computable format. Phase I involves evolving the framework into a fully specified economic model. The following steps will need to be undertaken to complete this phase of the project.

Specification of Economic Model

This step is purely conceptual and will rely primarily on the existing elements of the proposed framework and the data gathered from the literature review and site visits. To ensure model computation, the elements of the proposed framework will need to be defined more precisely in a mathematical manner. The specification must include all relevant equations, functional forms

for certain aspects, such as utility functions (specifying, for example, whether the utility function is log linear or constant relative risk aversion), laws of motion for the distribution of uncertainty related to costs and benefits, and demand functions for physician services. In addition, the specification must clearly state all model assumptions.

Verification of Economic Model

In this step, the fully specified economic model will be reviewed and its specification, including all assumptions, will need to be validated by experts in health economics. Based on feedback from the experts, the model will be modified and a final specification developed.

Approach to Model Computation

In this step, a high-level approach to computing the model will need to be developed. This high-level approach should include discussions of the algorithms that could be used to compute the model. For example, the current framework specification is based on a class of models referred to as recursive or dynamic programming models. There are many different approaches to computing recursive models, and, in this step, these alternative approaches will need to be discussed and a candidate approach recommended.

To fully validate the economic model, requires testing the model against actual data. We describe alternative data collection approaches below.

9.2.2 Phase II: Data Collection

This section discusses approaches to collection of data needed to validate the model developed in Phase I. We specify the types of data that need to be collected and their associated sample sizes. In addition, we describe alternative approaches to collecting the required data. Our approach to data collection is based on the literature review, proposed framework, and discussion guide used during our site visits.

Types of Data

Validating the economic framework requires data on a number of variables hypothesized as relevant to EMR adoption in small practice settings. The variables for which data must be collected are the same as the variables described in our site visit instrument. The site visit instrument provides greater detail about these questions (see Appendix C). However, this section presents a list of major variables for which data will need to be collected. These variables include—

- ▶ *Practice demographics:* Size, staff mix, specialty, age, physician tenure, geographic location, practice ownership
- ▶ *Billing and income:* Average pretax income per year, annual revenue, annual operating costs (labor and non-labor), insurance mix (e.g., Medicare, Medicaid, private insurance), type of reimbursement (e.g., fee for service, capitation), size of patient population, number of patient visits.

For non-adopters—

- ▶ *EMR experience*: Description of EMRs, past experience with EMRs (e.g., types of functionality, years of experience with EMRs)
- ▶ *Perceived benefits*: Revenue, safety, quality of care, workflow efficiency, cost reduction
- ▶ *Barriers to adoption*: Uncertainty about benefits, difficulty assessing technology, uncertainty about technology.

For adopters—

- ▶ *EMR understanding and experience*
- ▶ *EMR research and decision-making process*: Types of research, costs associated with conducting research, time to make decision
- ▶ *EMR purchase and implementation*: Functionalities purchased, costs of acquisition and implementation, annual upgrade costs and licensing fees, years since implementation, financing of EMR purchase
- ▶ *EMR benefits*: Cost savings, revenue enhancements, quality of care, safety, improvements in workflow efficiency.

We do not anticipate major changes to the variables included in our site visit instruments. However, it will be necessary to verify that all relevant variables have been captured once the economic model is fully specified and Phase I is completed.

9.2.3 Sample Sizes

To ensure robust validation of the framework, data need to be collected from a statistically valid sample drawn from practices with one to nine physicians. To calculate the sample size, we first examined the distribution of all physicians in the United States. We relied on the most recent publicly available data published by the American Medical Association (AMA) in its Physician Marketplace report.

According to AMA estimates, there were 668,939 patient care physicians in the United States in 2001. Of these, 413,280 physicians were either self-employed or employed in practices owned by other physicians. The remainder was employed by institutions, such as hospitals, medical schools, and universities. We excluded physicians employed at institutions from the sample size calculation because these physicians work in settings wherein the dynamics and reasons for EMR adoption may be very different from small physician-owned practices.

Of the group of 413,280 physicians, 313,595 were employed in practices of nine or fewer physicians. Exhibit 40 shows the distribution of these physicians by size.⁹⁴⁵

Exhibit 40. Size Distribution of Small Practices

Size	Number of Physicians
1	137,063
2-4	109,217
5-9	67,315

We used Exhibit 40 as a basis for calculating initial sample sizes. The sample size is determined by the level of precision one wants to achieve with parameter estimates. Obtaining parameter estimates (for EMR adoption among small practices) that have a margin of error of 10 percent requires a sample size of approximately 1,600 practices for each of the subgroups listed in Exhibit 40, yielding a total sample of 4,800 practices. Such an extensive data collection effort would be expensive, and one would need to consider tradeoffs between accuracy of parameter estimates and costs associated with the associated data collection. It may not be worthwhile to strive for such high accuracy because other model misspecifications may contribute to inaccuracies in parameter estimation. Alternatively, for the purposes of primary data collection, one could consider a sample size of approximately 2,400 practices, or 800 practices per subgroup listed in Exhibit 41. Although there is an inverse relationship between sample size and error, the relationship is not proportional. A total sample of 2,400 practices results in a margin of error of approximately 14 percent. Any data collection effort would need to address this tradeoff in determining the sample size.

9.2.4 Data Sources

We believe there are two options for obtaining the data needed to compute and validate the model. The first option is to examine any existing unpublished survey data and determine if these data sets can be used to validate the economic model. The second option is to gather primary data by administering a survey. There are pros and cons associated with each of these approaches, and weighing the amount of time and resources required against the ability to generate all of the required data will determine the choice of approach. We discuss each of these options in the following sections.

9.2.4.1 Use existing data sources

Determining whether the data from existing data sources can be used to validate the economic model would involve establishing partnerships with authors of existing survey articles (Gans, Burt and Sisk, or Audet) and exploring the feasibility of using these data sets alone or in combination for model computation and validation. This due diligence would involve obtaining the data sets from the authors—along with the respective data dictionaries—to ascertain the availability of all needed data, identify any gaps, and assess implications of unavailable data for model validation. We have examined the publicly reported data from these data sets to determine data availability for model validation. Exhibit 41 displays the relevant variables and availability of data.

Exhibit 41. Availability of Data for Model Validation

Relevant Variables	Data Availability	
Practice Demographics <ul style="list-style-type: none"> • Size • Specialty • Age • Practice ownership • Geographic location • Staff mix 	Data on these variables, with the exception of staff mix, is available from survey data. This data, although relevant, is not sufficient to fully validate the model.	
Billing and Income <ul style="list-style-type: none"> • Physician income • Annual gross revenue • Annual operating costs • Patient insurance mix • Size of patient population • Number of patient visits 		
For Non-Adopters <ul style="list-style-type: none"> • Description of EMRs • Past experience with EMRs • Perceived benefits • Barriers to adoption 		Some of this data is available from surveys. However, these surveys were not limited to small practices.
For Adopters <ul style="list-style-type: none"> • EMR understanding and experience 		
<ul style="list-style-type: none"> • EMR research and decision-making process (e.g., types of research, costs associated with conducting research, and time to make decision) 		Data not available from public sources
<ul style="list-style-type: none"> • EMR purchase and implementation costs 		Except for Miller, the data cited in other sources is not very reliable. Data on purchase and implementation costs is based primarily on expert opinion. Although the Miller study reports on costs, the data is based on case studies and a small sample.
<ul style="list-style-type: none"> • EMR benefits 	Similar to the data on costs, reliable sources of data on benefits associated with EMRs in small practice settings do not exist. The data that is available has been extrapolated from other care settings.	

As seen in Exhibit 41, the publicly reported survey data does not contain certain data elements. In addition, some critical data elements, such as costs and benefits, are based on case studies or expert opinion and do not represent accurate estimates. It is possible that the survey data contains some of these relevant variables even though the variables are not publicly reported. Determining whether or not certain data exists would require an examination of unpublished data from these surveys.

If unpublished data are available from existing survey studies, this would be the most cost-effective option for data collection.

9.2.4.2 Collect primary data

If it is determined that using existing survey data is not a feasible approach to validating the model, one would need to gather primary data to help validate the model. There are alternative approaches to primary data collection that have differential time and cost implications.

Collaborate with Existing Survey Studies

In this option, one could collaborate with existing studies or surveys to collect the needed data. Candidates for collaboration include the authors of existing surveys or studies undertaken by ONC, or other authors. Existing surveys would need to be augmented with a set of questions aimed at gathering data relevant to model validation. Specific questions would relate to the areas discussed in 9.2.1. This approach may require Office of Management and Budget (OMB) clearance.

Although this option may be more cost efficient, time efficiency may depend on the ability to identify the appropriate partners and timeframe within which the partner can operate. In addition, it is important to ensure that the surveys are administered to an adequate number of small practices to ensure robust data exist for model validation.

Administer Survey De Novo

The second option is to develop and administer a survey to a set of randomly selected small practices. This data collection approach would involve the following steps:

Develop survey instrument: First, a formal survey instrument would need to be developed. The instrument would be designed to collect data in the areas discussed in 9.2.1. It would rely heavily on the site visit instruments already developed.

Pilot the instrument: Next, the survey instrument would be piloted. Findings from the pilot can be used to modify the survey.

Create a sample of small practices: Concurrent with survey development, a sample of small practices would need to be generated. To create this sample, a list of all small practices would need to be obtained from various organizations, such as AMA. Using this list, a stratified random sample of small practices would need to be generated using the sample size calculations described in 9.2.3. In 9.2.3, size was the only stratification variable used. If additional variables are used to create strata, then appropriate sample sizes need be recalculated for the new strata. Additional variables for stratification include specialty, geographic location, and age—all of which have been shown as significantly related to adoption.^{946 947 948}

Administer survey: Next, the survey would need to be administered. The medium of administration could be telephone, mail, web-based, or some combination of these methods. Gans, for example, used all three methods to maximize response rates.

Prepare data: Finally, the data would need to be cleaned and analytic files would be created for use in model validation. The data collected through these surveys could then be used to estimate and validate the model.

Although this approach ensures maximum control over survey development and data collection, it would be more costly than approaches described above. In addition, adequate response would be essential to ensure ample data are obtained for model validation.

9.2.5 Phase III: Model Validation

The final phase involves using the data collected in Phase II to compute or estimate the model and then validate the model developed in Phase I. There are two approaches to this phase: (1) model calibration and computation and (2) statistical estimation.

9.2.6 Model Calibration and Computation

In this option, the model would be computed rather than statistically estimated. This approach can be used if examination of the unpublished data from existing surveys yields most if not all of the data necessary for model validation. This approach is akin to model simulation. The specific steps in model calibration and computation include:

- ▶ *Calibrate model parameters:* Based on the model specification, a list of parameters would need to be created. These parameters would then be calibrated (i.e., values will be assigned) using available data.
- ▶ *Develop algorithm to compute model:* In this step, an algorithm would need to be specified to compute the model. The purpose of the algorithm would be to define the sequence of steps that need to be undertaken to numerically solve the model. The algorithm would begin with the parameter specification and would then detail the steps involved in the numerical solution to the utility maximization problem specified in the framework. This step is similar to writing pseudo code and is designed to help develop code to compute the model.
- ▶ *Write code and compute model:* The algorithm specified in the previous step would be used to write computer programs and generate the model solution. We are not aware of any COTS software that can be used to compute the model. Programs would need to be written to solve the model. One could use Matlab or C to write these programs. The code would need to be debugged and tested for accuracy. The numerically computed model would help generate practice level and industry-wide adoption curves.
- ▶ *Run sensitivity tests:* Once the model has been computed, one could conduct sensitivity analyses by examining the behavior of the model under alternative assumptions for parameter values. For example, one could examine the impact of changes to specification of the uncertainty associated with EMR costs and benefits on adoption behavior.

The model calibration and computation approach could be useful to because it would:

- ▶ Facilitate validation of the model by examining the behavior of the model against adoption rates from the survey data
- ▶ Allow testing the effects of changes in model parameters, including costs, benefits, and their respective distributions. For example, one could change assumptions about the probability distributions of the cost and benefit functions and examine the effect of these changes in uncertainty on adoption rates. Another test could be to change the information flows to practices and determine how much of an effect the change has on adoption.

The model calibration and computation approach could be useful in understanding physician behavior and examining how changes in relevant variables affect adoption. The predictions of such an approach may not be as robust, because not all model parameters are based on actual data.

9.2.7 Statistical Estimation

In a statistical estimation approach, the model would be estimated statistically using the data collected in Phase II. Of the two approaches to model estimation, statistical estimation poses the most stringent data requirements: data type and accuracy. The purpose of model estimation would be to arrive at values of the underlying parameters using data gathered from small practices. Parameter estimates cannot readily be drawn from the literature. The specific steps needed to execute this approach are similar to the steps involved in model computation, described in Chapter 9.2.6. They include—

- ▶ *Calculate descriptive statistics:* Using the data collected in Phase II, descriptive statistics would be calculated to examine data properties. This step would also help with data cleaning and examination of missing or anomalous values.
- ▶ *Develop algorithm:* If it is determined in Phase I that COTS software to estimate the model does not exist, then an algorithm would need to be developed. The algorithm would need to specify the steps required for structural nonlinear estimation (similar to maximum likelihood regression estimation) of a multi-period dynamic model. As described in 9.2.6, the purpose of this step is to help develop programming specifications.
- ▶ *Write program and estimate model:* Using the algorithm described in the previous step, actual computer programs would need to be written to estimate the model. The code would need to be debugged and tested to ensure accurate model estimation.
- ▶ *Run simulations:* Using the estimated parameters from the previous step, one would run simulations that examine the effect of changes in the model on adoption behavior. This step is similar to the final step described in 9.2.6.

This approach has more stringent data requirements than the one described in Chapter 9.2.6. If data are available, the parameter estimates would likely be more robust; therefore, the simulations based on statistical estimation would be more reliable. The major challenge is that under statistical estimation, it is important to specify the model in Phase I as close to the real world as possible. Any deviations from the real world (driven by the necessity to abstract and

prevent specification of a highly complex mathematical model that may be intractable) can lead to model misspecification, which could potentially lead to biased parameter estimates. Any simulations using these biased estimates may result in weak or inaccurate conclusions.

9.2.8 Hybrid Approach

One could pursue a hybrid approach to validating the economic framework. The hybrid approach is a two-step process that provides short-term and a long-term strategy to validate the model. In this approach, the economic model (described in Phase I) would be developed, and model calibration and simulation would then be performed using unpublished data from existing surveys. In addition to model calibration and simulation, primary data could be collected in the long-term. The data from this data collection effort could then be used to perform more robust computation and model validation.

9.3 Conclusion

In this chapter, we discussed options to validate the economic framework. These options include calibration and simulation, as well as structural estimation of an economic model. The successful execution of these options depends on the availability of data. Collection of primary data, whether in the near or medium term, will be critical to the utility of the economic model for understanding adoption and exploring relevant policy options. It is important to consider the time and cost implications of these options and select the approach in the near term that represents the most cost-effective option.

10.0 EMR Implementation Roadmap

10.1 Introduction

Small ambulatory practices may consider electronic medical record (EMR) implementation for a number of reasons. Practices may want to enhance efficiency in terms of patient through-put, workflow management, access to and legibility of chart information, prescription and refill processing, and appointment scheduling. Physicians may want to avoid medical and administrative errors to improve quality and prevent litigation. Hartley and Jones suggest that practices may want to improve billing timelines and claim/billing code accuracy.⁹⁴⁹

We conducted site visits and phone interviews to gather information and lessons learned about EMR implementation in small physician practices. As necessary, we supplemented this information with a scan of literature on implementation. In this chapter, we have synthesized the information from the site visits, interviews and literature scan to provide a generalized implementation roadmap for small practices (of 1-9 physicians) considering EMR implementation. This document provides an overview of lessons learned over the course of the ASPE project entitled “Assessing the Economics of EHR Adoption and Successful Implementation in Physician Small Practice Settings.” It should be viewed as a guide to help physicians in understanding the issues related to EMR purchase and implementation.

10.2 Develop Understanding of EMR Functionalities

The EMR landscape can be complex and intimidating to those unfamiliar with it. Physicians and practices considering implementation should first familiarize themselves with common terminology and EMR functionalities. We have provided an overview of several EMR-related acronyms in the exhibit below. This list is not comprehensive, and we suggest that practices supplement this list with additional research on EMR-related acronyms and terminology. Glossaries created by organizations such as the Institute of Medicine and HL7 may be useful.⁹⁵⁰

Exhibit 42. EMR-Related Acronyms

Acronym	Explanation
CCR	Continuity of Care Record
CPOE	Computerized Physician Order Entry
CPR	Computerized Patient Record: Alternate term for EMR ⁹⁵¹
EPR	Electronic Patient Record: Alternate term for EMR ⁹⁵²
e-Prescribing or eRX	Electronic Prescribing
PHR	Personal Health Record: Similar to EMR; created and owned by the patient ⁹⁵³
PMS	Practice Management Software

Practices should note that terminology may vary from vendor to vendor, and that the industry is moving toward using the term “electronic health record” (EHR) in general, so it is important to thoroughly understand the specific tools and functionalities provided by each system regardless of descriptive terms used. Practices are advised that the EHR Vendor Association (EHRVA) is

adopting a consistent terminology, which may improve this situation and eliminate older terms such as CPR and EPR.⁹⁵⁴

Practices may have varying perceptions of EMR systems. For some practices, an EMR system may simply be viewed as a means of achieving electronic documentation. For other practices, an EMR system may be viewed as a comprehensive office and workflow management tool. It is important to understand the scope of available EMR functionalities to make an informed decision about the system that best matches the practice's needs. For an EMR to be interoperable and transportable, healthcare providers are encouraged to evaluate software that enables health information to be read, edited, transmitted, received and understood.⁹⁵⁵ The Institute of Medicine has defined 8 core EHR functionalities:⁹⁵⁶

- 1. Health Information and Data:** EHR systems with defined capabilities include features such as medication lists, allergy lists, patient demographics, clinical narratives, laboratory and other diagnostic test results, and medical diagnoses.
- 2. Results Management:** Electronic results can significantly benefit providers in the management of all types of results, to include laboratory, radiology, and other various procedures. This capability allows providers enhanced access to information which enables the provider to make quicker treatment decisions.
- 3. Order Entry/ Management:** CPOEs can significantly improve operating processes in several ways such as eliminating duplicative and ambiguous orders, and in some instances orders can be automatically generated. This results in time savings for both the patient and provider.
- 4. Decision Support:** Such systems may support medication prescription (dosing and drug selection), diagnosis, and detection of adverse events. Increasingly, decision support systems are being used in disease treatment and management, improving adherence to established evidence-based guidelines.
- 5. Electronic Communication and Connectivity:** The benefits of this functionality are particularly relevant to those patients that access the healthcare system in various settings, such as patients with chronic disease, who require well-coordinated plans of care.
- 6. Patient Support:** Applications that enable patients to take greater participation in their own care are important. Patient education has demonstrated significant effectiveness in improving control of chronic illnesses.⁹⁵⁷
- 7. Administrative Processes:** Electronic billing and coding is a function that is not only timelier, it reassures providers that coding levels are maximized and reduces the fear of fraud and abuse associated with coding. Similarly, insurance verification can be processed at the point of service, which not only reduces administrative burdens, but allows patients to maximize their healthcare benefits.
- 8. Reporting & Population Health Management:** Without computerized functionalities many clinical quality indicators, which are the keystone for clinical Quality Improvement, must be derived from data that is extracted from many sources (claims data, etc.), which is very burdensome and time intensive. However, EHRs provide a readily available and standardized process to capture clinical outcomes, which in turn can result in improved

clinical quality. Reporting capabilities are also enhanced, such as disease surveillance and other mandated indicators.

Practices are encouraged to evaluate EMR systems for the availability of these core functionalities as well as other features that may be included. The Certification Commission of Healthcare Information Technology (CCHIT), a voluntary private sector initiative to certify HIT products, has also published functional capabilities for Ambulatory EHRs and associated criteria for comment. These categorizations of EMR/EHR functionalities demonstrate an industry-wide movement toward standardization. For any given EMR functionality, there may be multiple options available at varying levels of complexity. For example, notes can be created electronically via templates, free text, check boxes, macros and speech recognition.^{958,959} Each of these approaches to functionality has different implications for usability, interoperability, costs and benefits. The exhibit below illustrates different approaches to providing the same functionality. The pros and cons of each of these approaches should be considered for each practice.

Exhibit 43. EMR Functionalities and Options

Document	
Text	Unstructured
	Structured/Template
	Structured with Categories
Data Entry	Typed
	Structured Data Entry
	Dictation
	Voice Recognition
	Handwriting Recognition
Alerts	None
	Basic (e.g., preventive service reminders)
	Advanced (e.g., clinical guidelines)
Reports	Custom (specify)
View Results	
Type	Lab Results
	X-Ray Results
	Image Viewing
Alerts	None
	Basic (e.g., reminders with critical values)
	Advanced
Communication	Fax Only
	Email and Fax
	Intra-System
	External to Lab (How many labs?)
Reports	Custom (specify)
Order Medications	
Text	Unstructured
	Structured/Template
	Structured with Categories
Data Entry	Typed
	Structured Data Entry
	Dictation
	Voice recognition
	Handwriting recognition
Alerts	None
	Basic with Reminders
	Advanced
Checks	None
	Allergy and Interaction
	Allergy, Interaction and Alternative Drug Suggestion
	Available Formulary
Communication	Print for Patient
	Print and Fax
	Pharmacy Connection – One Way
	Pharmacy Connection – Two Way
	Multiple Pharmacy Connections
Order Tests	
Text	Unstructured
	Structured/Template
	Structured with Categories
Alerts	None
	Basic (e.g., reminders with critical values)
	Advanced
Communication	Fax Only

	Email and Fax
	Intra-System
	External to Lab (How many labs?)

Experts advise that more advanced EMR systems may include office and clinical workflow management functionalities, such as: ability to define and modify workflows, worklists for active cases, reminders for work items that have not been completed when due, and others. Workflow management systems may deliver customized workflow around a practice's current workflow process for gathering data. For example, a practice may currently use a paper-based workflow system that they like. An EMR workflow management system can be configured, through use of its definition editor, to precisely match this preexisting workflow.⁹⁶⁰ Workflow functionalities are relatively new in the market and may not be available from all vendors. In addition to EMR functionalities, other important implementation considerations include costs of necessary hardware and infrastructure; availability of support; and the overall effects of the EMRs' implementation, installation, integration, interface and interoperability on the practice's return on investment. The implementation will require considerable planning and management and the installation may be disruptive to usual business. Implementation may interfere with revenue at a time when revenue is already diminished.⁹⁶¹ The choice of EMR system interface may have significant impacts on usability and user satisfaction. The implementation of EMRs can provide practices with a number of benefits, including:

- ▶ Increased patient throughput;
- ▶ Improved workflow;
- ▶ Reduced or eliminated transcription fees;
- ▶ Improved patient safety through functionality such as using allergy and adverse drug reaction notification;
- ▶ Improved patient communication and relationships; and
- ▶ Enhanced drug recall.⁹⁶²

The level of interoperability of the EMR with other systems internal and external to the practice is likely to impact the type and magnitude of benefits realized. Anecdotal evidence suggests that another factor that impacts the success of implementation and the benefits gained is the ability to customize the EMR to match practice workflows (both office and clinical). Even for solo and small practices, the resulting improvements in workflow allow for increased patient volume and increased revenue. Alternatively, practices could choose to maintain steady patient volumes and spend additional time with each patient.

To develop a thorough background on EMRs and implementation, practices are encouraged to conduct additional research.

Selected EMR and Implementation Resources

- ▶ American Academy of Family Physicians' Center for Health Information Technology
<http://www.centerforhit.org>
- ▶ EHR Central
<http://www.providersedge.com/index.html>
- ▶ EHR Web <http://www.ehrweb.org>
- ▶ Healthcare Information and Management Systems Society (HIMSS) <http://himss.org>
- ▶ Medical Records Institute
<http://www.medrecinst.com>
- ▶ Medicare Quality Improvement Community)
<http://www.medqic.org>

Practices should note that this list is not comprehensive. Booz Allen encourages practices to seek additional resources that may be available.

Evidence from interviews suggests that practices can learn a great deal about specific systems and EMRs in general by participating in internet chat room discussions and mailing lists. A number of health industry organizations provide helpful online information on EMRs and implementation as well. Practices should note that some information sources may also sell services and products, so advice from these sources may be biased. In addition to online resources, there are numerous EMR and implementation publications available. Practices are encouraged to search PubMed for additional useful resources.

10.3 Conduct Internal Preparation

For small practices, EMR implementation represents a significant investment of time, money and resources. To maximize the impact of this investment, practices should thoroughly prepare for implementation by assessing readiness, understanding the potential areas for improvement within the practice, and determining implementation goals and requirements. This will enable the practice to map EMR functionalities to implementation goals and requirements. As EMR implementation will impact clinical processes for many years, practices must exercise due diligence in researching, planning for, selecting and implementing the most suitable system.⁹⁶³

10.3.1 Internal Assessment and Planning

The first step that a practice should undertake while internally preparing for EMR implementation is to assess its readiness. Practices should understand why an EMR is wanted/needed and how it fits into the existing business plan. Although a practice's goals and EMR system requirements may change over time, it is important to develop a baseline understanding of the initial implementation goals and requirements. Alignment with strategic and clinical objectives is critical to a successful implementation.⁹⁶⁴ Evidence from site visits suggest that the implementation of an EMR that does not match the practice's needs, budget and level of readiness can be disastrous.

In one case, a small practice implemented the EMR offered by its current Practice Management Software (PMS) vendor. After spending two years and \$100,000 on this implementation, the practice abandoned the EMR in favor of a new PMS-only system. This practice required over a year to recover financially. Within the last 6-8 months, this practice began to revisit the possibility of EMR implementation. Other practices interviewed had similar experiences, resulting in abandoned implementations. To avoid similar circumstances, Adler recommends developing a plan so that vendors do not "control the selection process."⁹⁶⁵

As part of the internal preparation and assessment, practices should inventory existing hardware, systems, processes and workflows to identify areas for improvement. Potential areas for clinical and office workflow and process improvement could include: time spent looking for charts, time on phone trying to contact patients to verify details, inclusion of lab results in charts, clarity and legibility of notes, and the billing/claims process. Existing hardware and software systems may be outdated or may not have sufficient capacity/capability for use with the new EMR system. The practice may not have the necessary hardware at all, in some cases. Practice staff will have varying levels of technical skills, abilities and computer savvy so it may be beneficial for the

practice to gauge the baseline staff skill-level. Evidence from interviews suggests that computer savvy practices tend to have more successful implementation experiences. For those who are not computer savvy, it may be possible to provide basic computer training if necessary.⁹⁶⁶ A simple time and motion study is one method of understanding practice workflow and developing a baseline for measurement of post-implementation progress.⁹⁶⁷ Practices should explore other possible approaches as well, to prevent undue burden on practice resources.

Interactions with other practices may be able to be improved through the use of an EMR with workflow management capabilities. For example, an allergist may share some steps with a primary care specialty (e.g., vitals collection, medication documentation) while having additional unique needs. One expert advises that "... if an allergist is to work with a family medicine or pediatric specialist, it is not practical to use separate EMRs, one of which is designed for allergists. Instead, they can share an EMR and rely on the workflow engine to execute separate different workflows that are designed into the system using the process editor. The same EMR can exhibit different workflow in different clinical circumstances for different people. An EMR without a workflow management system, without the ability to execute different process definitions depending on context, cannot accomplish this."⁹⁶⁸

It is recommended that physicians (as opposed to office support staff) should lead the EMR selection effort.⁹⁶⁹ Multiple sources (from interviews, site visits and the literature) advocate that a "physician champion" should drive the effort through research, management of the process, and promotion of the importance of EMR implementation to build commitment among practice members.^{970,971,972} This individual usually has to commit significant uncompensated time to the effort, but may be essential to successful EMR selection and implementation. Interviewees particularly emphasized the importance of a committed champion in guiding the implementation effort since it may require substantial time and attention. It may be best to involve the most influential practice members (e.g., practice manager or delegate, key nurse) in the decision process as well.⁹⁷³

The entire practice should be prepared for the EMR implementation with key messages geared toward building commitment to entering clinical data.⁹⁷⁴ It may be beneficial for small practices to consult with the local health and physician community about EMR implementation. This will allow a practice to benefit from the experience of colleagues and gather advice and lessons learned while identifying potential integration challenges. Also, practices may want to research the systems implemented by other similar practices, as some EMR systems allow practices to share templates.

When considering implementation, it is important for the practice to identify and define the goals and requirements of the EMR system and ultimate implementation. This planning ensures alignment with the practice's business plan. Goals and requirements will vary from practice to practice and may include E-prescribing, ability to print patient education information easily, decision support, secure patient email capabilities, and connectivity with business partners.^{975,976} Practices should factor in future (long-term) goals and requirements as well (e.g., fully paperless office, high level of connectivity with labs, full compliance with HIPAA requirements).

10.3.2 Mapping EMR Functionalities to Implementation Goals and Requirements

Once a practice has developed an understanding of its readiness, and defined the goals and requirements of EMR implementation, it should then identify EMR functionalities that map to these goals and requirements. For example, if the practice is seeking an electronic documentation tool, it may not be necessary to purchase an EMR with additional advanced features. This mapping will involve research and analysis to determine the EMR system and implementation approach that is best for the practice, and for interoperability with local health community. Adler suggests that practices should develop a prioritized list of EMR functionalities to help clarify implementation goals.⁹⁷⁷

EMR systems may use different types of technology. Hartley and Jones describe three technology approaches when considering EMR implementation:⁹⁷⁸

- ▶ Client Server software licensing: Vendors charge a one-time licensing fee per user and prices may range from \$15,000 to \$50,000 per physician, though the price can reach \$100,000 for a solo specialty practice
 - Health data are stored on-site on a client server, and may be remotely backed up or backed up with tapes
- ▶ Application service provider (ASP) plan: Vendors charge monthly fees per user and prices range from \$99/month to \$700/month; with some vendors assessing monthly fees for specific transactions and taking a percentage of any fees collected from online virtual medical office visits
 - Health data are stored off-site
- ▶ Hybrid of Client Server and ASP: This combination is emerging in practices with multiple locations or by groups of small physician practices who come together to make a co-operative purchase through an Independent Practice Association (IPA) or Managed Service Organization (MSO)

The ASP approach may provide cost savings in terms of hardware requirements since the vendors will store and maintain associated hardware.⁹⁷⁹

It may be cost-effective for practices to adopt a modular implementation approach to achieve near- and long-term goals while incrementally enhancing capabilities.^{980,981} For instance, practices may begin with a focus on reducing administrative costs, using modules for:

- ▶ Data capture and data access for EMRs (e.g., search, accessibility and security);
- ▶ Medical transcribing;
- ▶ Electronic prescriptions; and/or
- ▶ Billing and charge capture.⁹⁸²

Once this basic EMR infrastructure is in place and the culture of the practice has adapted, it may be beneficial to implement a decision support module for enhanced functionality.⁹⁸³ This

approach allows practices to implement the modules that are most beneficial and highest priority, without having to necessarily implement less relevant modules.

In addition, practices must consider whether to seek an integrated EMR system (where PMS and EMR are built on one set of data tables) or a “best of breed” system (where data are transmitted between PMS and EMR).⁹⁸⁴ Vendors may be national or regional.⁹⁸⁵ The practice may prefer wireless or wired connections, and should consider the pros and cons of tablet PCs, touch screens, laptops and desktops.⁹⁸⁶ These preferences and ultimate choices will impact infrastructure requirements (e.g., carts for laptop mobility, docking stations for tablet PCs).

As part of the planning process, practices should develop a budget that reflects savings against expenditures.⁹⁸⁷ This budget should account for initial and recurring costs associated with hardware, software and services.⁹⁸⁸ Hardware costs may include servers, workstations, printers, fax machines, tablet/laptop PCs, PDAs, hubs, switches, routers, cabling, and others. Software costs may include the EMR itself plus add-on or support applications such as interfaces, PMS and lab systems. Service costs could include technical support, training, and consulting. Practices should note that the highest priced EMR system is not necessarily the most appropriate. Hartley and Jones suggest that it may be possible to find a \$5,000-\$10,000 system that suits the practice’s needs and budget.⁹⁸⁹

10.3.3 Tools for Internal Preparation

A number of tools exist to support internal practice preparation and evaluation. The process of developing a Request for Proposal (RFP) may facilitate internal practice evaluation. Adler suggests that the development of a RFP can be beneficial because it informs vendors of key characteristics and priorities of the practice. Further, he states that the RFP responses facilitate side-by-side comparison of EMR systems.⁹⁹⁰ There are sample RFPs available on the internet, however, practices should be cautious when using a RFP created by another practice or for another purpose. The differences in characteristics, specialties and priorities across practices make generic RFPs of limited value. However practices may adapt RFPs used by similar practices and customize them for their own needs. Alternatively, practices could conduct informal internal analyses and create simple checklists for EMR requirements and goals. Evidence from site visits and interviews suggests that the development of a RFP may be too time-consuming and effort-intensive for some practices. Interviewees have experienced successful EMR implementations by conducting research and preparations without developing and distributing a RFP. It is a matter of preference for individual practices.

As part of the internal preparation process, practices may want to consider engaging an IT consultant or an EMR-focused IT consultant. Evidence suggests that an IT consultant can be very helpful during the overall EMR implementation process. Several practices interviewed and visited indicated that an IT consultant was significantly helpful in many aspects of implementation, such as hardware and infrastructure acquisition and set-up and understanding software and system requirements. An EMR-focused IT consultant may also be able to assist with site preparation, contract negotiation; and EMR system set-up and customization. For practices with no internal IT personnel or capabilities, an EMR-focused IT consultant can

provide much needed expertise. For practices with internal IT resources, an EMR-focused IT consultant can work with practice IT staff to expedite and facilitate implementation.

10.4 Identify and Evaluate Potential Vendors

There are a number of options for identifying and evaluating potential EMR vendors. If the practice chooses to use a RFP for vendor selection, Adler suggests only sending the RFP to a limited number of likely candidates because the RFP response process can be time consuming.⁹⁹¹

In order to make an informed decision, it is necessary for practices to research potential vendors. Practices should go beyond research on the EMR systems and gain an understanding of vendors' positions in the marketplace. It is recommended that practices exercise caution in working with small vendors with a limited client base.⁹⁹² Practices are advised to consider the potential longevity of the vendor as well.

Practices could consider numerous criteria while prioritizing vendors and EMR systems. Experts suggest that the criteria should include the following:

- ▶ EMR system's compatibility with the existing Practice Management Software (PMS);
- ▶ Vendor's history of marketing to small practices;
- ▶ Vendor's current clientele (e.g., the number of small practices starting to use the system); and
- ▶ Availability of published ratings on the EMR system.^{993,994}

In evaluating EMRs, it is also important for practices to consider how the system fits in with existing workflow. In addition, practices should consider the ability of the EMR to integrate into and adapt to the workflow already in place. Experts advise that the ability to tailor EMR workflow to existing workflow may mitigate the shock associated with injecting new IT systems into the practice. As an example, a pediatric practice may require a nurse to review immunization status for each patient to anticipate and prepare necessary vaccinations before the documenting of vitals and chief complaint at the time of the visit. An EMR workflow management system can accommodate this "in just a couple clicks of the process editor." Experts also indicated that once users have acclimated to the new technology, "a couple more clicks can begin to change workflow in other beneficial ways that might not have been possible if required to change a lot of workflow at once."⁹⁹⁵

Compatibility with existing hardware and software could be especially important in terms of cost and efficiency. An EMR system that is not compatible with the existing PMS system will lead to dual data entry since information cannot be shared between systems. Practices should note that interfaces between the EMR and PMS systems will need to be upgraded as the software is upgraded.⁹⁹⁶ The implementation of a system that requires significant investments in new hardware can be complex and more labor and cost-intensive than anticipated.

There are numerous evaluations of EMR systems available online as well. Practices should leverage the evaluations from reputable sources, as this may eliminate some of the legwork

involved in vendor research. Adler recommends that practices review existing evaluations of EMR systems, such as those created by Aurora Consulting Group, the annual TEPR (Towards the Electronic Patient Record) conference and the AAFP's Center for Health Information Technology. Practices may even want to consider attending the TEPR conference. Practices may want to read or participate in physician blogs (such as www.emrupdate.com) to learn what other physicians say about system implementation and ease of use for specific EMRs.⁹⁹⁷ Additional considerations for prioritizing vendors could include the potential interfaces with other systems and partner organizations, available training and implementation support options.^{998,999}

At this point, the practice should synthesize all research to identify the three to four most promising vendors. Additional processes of elimination should allow the practice to ultimately select the vendor that best complements its workload, workflow, budget, goals and requirements.¹⁰⁰⁰

One significant element of vendor and EMR system research is hands-on experience. Practices should test multiple EMR systems to determine the characteristics and interfaces that best meet implementation goals and requirements. It may be possible to test systems by "test-driving" the EMRs implemented by colleagues. One interviewee indicated that this was an important factor in the practice's EMR selection. Many vendors offer the ability to test EMRs via online demonstrations. In addition, it may be possible to learn about EMR systems by participating in medical society meetings.¹⁰⁰¹

For the most promising EMR systems and vendors, practices should schedule in-person demonstrations, validate references and explore financing options. It is important for practices to view and interact in a live demonstration prior to purchasing a system.¹⁰⁰² Vendor representatives are skilled at providing prepared and well-outlined demonstrations, but to learn whether the EMR will work for the practice, Adler recommends that practices do the following:

- ▶ Present 1-2 standard visit scenarios for the vendor to document using the system;
- ▶ Avoid interrupting the demonstration too frequently;
- ▶ Focus on features beyond note creation, particularly the EMRs capabilities around searching for information, viewing lab results, managing health maintenance reminders, writing prescriptions, and any other features deemed high priority by the practice; and
- ▶ Develop a vendor rating form in advance and have all attendees complete the form at the end of each demonstration.¹⁰⁰³

This approach facilitates the comparison of vendors and systems. For the most promising vendors, practices should check several references with varying perspectives (e.g., physician user, IT specialist, senior manager).¹⁰⁰⁴ Practices should acknowledge that vendors will likely only provide the happiest customers as references. This is where networking with the health community can be beneficial. If possible, practices should try to contact other sites that have implemented these EMR systems to get their references as well. These references may provide insight into the type and quality of support provided by the vendor after implementation, as well as the ability to customize the system to meet practice needs. It may be possible to conduct site visits at these facilities as well. If site visits are conducted, it is important for attendees to

observe physicians with patients, and to view the creation and entry of clinical notes.¹⁰⁰⁵ In weighing impressions from site visits, practices should note that the sites visited may have customized the EMR to suit specific needs or workflow. Mailing lists and the internet provide additional venues for references.¹⁰⁰⁶ This point in the process is also a good time for practices to ask business partners and colleagues for details on their return on investment measurement and strategies. This will facilitate the final ranking of vendors.

One of, if not the most important consideration in establishing rankings is the practices' priorities.¹⁰⁰⁷ Adler suggests formally weighing priorities related to functionality, total cost and vendor characteristics before establishing a final ranking of the top vendors/systems.¹⁰⁰⁸

In parallel with vendor research and preparation, practices may want to explore methods of financing EMR implementation. It may be possible to establish a collaborative purchase model with an Independent Practice Association (IPA), Managed Service Organization (MSO) or virtual IPA. Some practices interviewed used a combination of loans and out of pocket payment for EMR systems. Alternatively, practices may want to apply for grants to secure initial and/or continued funding. Interviewees have had success in obtaining grant funding for implementation of some functionalities, such as e-prescribing.

10.5 Select Vendor and Negotiate Contract

After completing a site visit for each of the top contenders, practices should re-examine the vendor ranking to ensure that it is still accurate.¹⁰⁰⁹ The negotiation process may impact rankings and could lead practices to move to another of the top choices. Also, Adler suggests that having a "serious back-up choice" will provide a practice a stronger position for negotiations.¹⁰¹⁰

It may be beneficial for small practices to engage an IT consultant to assist in the implementation process. An IT consultant should be able to assist in hardware acquisition and set-up as well. Evidence from interviews indicates that the use of an IT consultant significantly smoothed the implementation and installation processes.

EMR contract periods vary, and may cover anywhere from three to 10 years to lifetime.¹⁰¹¹ It is important for practices to understand what will happen after contract termination. Practices should ensure that the following details should be explicitly stated during negotiations:

- ▶ Nature of the contract (e.g., lease with monthly fees or purchase of software license with maintenance fees) and licensing structure if applicable;
- ▶ Specific products and services included and excluded (including amount of training provided);
- ▶ Current and future costs (e.g., upfront costs, training, annual fees, maintenance);
- ▶ Vendor role;
- ▶ Vendor's time commitment for the implementation process; and
- ▶ Contingencies for the possibility that the vendor goes out of business (e.g., request that the source code be put into escrow).^{1012,1013}

Experts also suggest obtaining the services of a Health IT or software contracts lawyer to assist in this process.^{1014,1015} Alternatively, practices may want to involve an IT consultant during software negotiations.¹⁰¹⁶ The IT consultant may be able to assist with negotiations for many features and options, such as free or discounted training, remote access and additional licenses. Interviewees suggest that practices should be particularly cautious about variable maintenance fees and increasing support fees. For example, a variable maintenance fee may start at 15 percent but increase over time or at the vendor’s discretion. This may create unanticipated budget shortfalls for unsuspecting practices. These particular costs should be specifically detailed and limited during contract negotiations to avoid unforeseen increases in costs over time.

Once the final negotiations are completed and the contract is signed, the practice should lay out a specific implementation strategy. This should include an implementation timetable with a specified date for the EMR system to “Go Live” and detailed training plans. In addition, the strategy should include planned communications with practice staff, patients and community partners.¹⁰¹⁷ At this stage, practices must secure the necessary hardware to support the EMR implementation. An IT consultant may be helpful in this regard as well. The AAFP’s Center for Health Information Technology has developed a sample implementation timeline specifically targeted at small medical offices. This conservative sample is presented in the exhibit below.¹⁰¹⁸

Exhibit 44. AAFP CHIT Sample Implementation Timeline¹⁰¹⁹

Three to four months before "go live"
<ol style="list-style-type: none"> 1. Install hardware in the patient rooms and common areas or purchase wireless equipment including tablets and/or laptops. It may be necessary to obtain a server, depending on the EMR selected. 2. Ensure the functionality of the network and hardware and validate that all components can communicate with each other. 3. Install and verify scanning and faxing capability (and other office automation capabilities, if applicable). 4. Accomplish any necessary basic computer training; seek feedback from staff and all involved. 5. Ensure that the team is working well together.
Two to three months before "go live"
<ol style="list-style-type: none"> 1. Establish protocols for scanning incoming information and faxing outgoing information. 2. Continue to build general computer skills and continue to receive staff feedback. 3. Install and test any ancillary programs which might either be required or be very helpful which includes speech-recognition programs, accessory faxing and scanning programs etc.
One to two months before "go live"
<ol style="list-style-type: none"> 1. Ideally, the EMR software would be installed at this time to allow the providers and office staff time to fully check out the system and make sure everything works. Sometimes this is not done because the training and installation is done at the same time by the vendor, very close to the “go live” day. Whatever the exact time between software installation and starting to see patients using the record, a few things should be checked out: <ol style="list-style-type: none"> a. Ensure that the software and hardware function as expected. Make sure that screen transitions are quick and that there is no lag in how the system is performing. b. Test the interoffice messaging system and make sure it is possible to fax prescriptions. c. Test printers. d. Scan some material into the record to test this functionality. 2. Decide what information needs to be put in to the patient's chart ahead of time and start doing this for patients coming in the first few weeks at least. 3. Run through some mock patients in order to get a feel for how the system is working and for patient flow through the office.

10.6 Implementation and Beyond

To manage the implementation and ensure a smooth transition to the new system, it is recommended that practices implement and troubleshoot the office automation components of the system prior to going live with the actual EMR. In addition, clinicians and staff should gain as much familiarity with the system (and new hardware) as possible before using it with patients.¹⁰²⁰ It is recommended that an intensive training session should be scheduled after the EMR system has been chosen.¹⁰²¹

It is important for practices to allow staff time to absorb any new training content. However, it is recommended that the “Go Live” date for the EMR system should be scheduled close to the end of training so information is not forgotten.¹⁰²² Training can be supplemented from within the practice if staff members are developed as internal trainers.¹⁰²³ It may be beneficial to develop policies and procedures for training new staff. Perhaps one practice member could be designated as the trainer for all new staff.

Once an EMR system has been implemented, practices will need to transition from the traditional paper records to the new EMR system. The preparation and internal assessment conducted earlier in the process will facilitate this switch from paper to electronic records. If the groundwork and commitment has already been laid, the practice should reinforce key messages at this time to ensure that staff demonstrate a continued commitment to entering clinical data in the new system to achieve a truly paperless environment.^{1024,1025}

This step requires planning and knowledge of the practice workflow. Hartley and Jones suggest that it may be beneficial to use a “hybrid system” that combines paper and electronic records for a brief transition period to allow staff to acclimate to the new EMR system and associated procedures while ensuring accuracy of patient information.¹⁰²⁶ However, practices are cautioned against prolonging dependence on paper.¹⁰²⁷ This transition can also be facilitated by training, in the form of webinars, quick reference guides, in-person training, in-house coaching, and online help desk or technical support.¹⁰²⁸

Hartley and Jones have compiled list of “Dos and Don’ts” for the hybrid approach to transitioning from paper to EMR. An adapted version of this list is provided in the exhibit below.

Exhibit 45. Hybrid EMR Dos and Don'ts¹⁰²⁹

Do:	Don't:
<ul style="list-style-type: none"> • DO Designate time and resources for training • DO Reduce patient load for a week during implementation • DO Expect the vendor to be on-site for system training • DO Identify paper triggers; compare designed workflow to actual processes with new system • DO Expect staff meltdowns at first (should subside within 2 months) • DO Build all new patient records using the EMR system • DO Expect the “physician champion” to provide encouragement, even when mistakes occur • DO Provide staff with a refresher course on HIPAA Privacy and Security Rules policies and procedures • DO Expect the vendor to accommodate the practice’s special needs • DO Provide patients with training on securely accessing their EMR (if applicable); ask for patients’ email addresses • DO Expect continued progress and IT adoption from partner organizations and others in the healthcare community 	<ul style="list-style-type: none"> • Don't Conduct training or implementation without external assistance, as lack of training is the primary cause of failed EMR implementation • Don't Schedule implementation during peak cold or flu season, or during any known high demand period • Don't Create duplicate (shadow) records, as this negates the purpose of going paperless • Don't Expect the vendor to be on-site for technical support • Don't Assume that all scanned documents are automatically searchable; some may require conversion, balancing and validation to be searchable • Don't Permit punitive actions as staff learn and adjust to the new EMR system • Don't Implement a web site or EMR capabilities without HIPAA policies and procedures in place • Don't Conduct this process without involvement of the vendor and IT consultant (if applicable) • Don't Leave patients out of the adoption equation • Don't Expect miracles, do expect collaboration

Interviewees emphasized that practices should expect a few problems to arise as the new EMR system is implemented. One physician interviewed cautioned practices to “temper your expectations, as the IT industry does not give informed consent.”

Once the EMR is installed and in use, practices should develop and deploy a plan and procedures for migrating paper chart information into the EMR. The migration of historical data into electronic format may improve the functionality of the new EMR system and enhance practice benefits. This can be a time-consuming process. Some sources suggest that it may not be necessary to scan entire paper charts into the EMR system.¹⁰³⁰ Essential patient data to be migrated includes: past medical, social and family histories; immunization records; medication and allergy lists; problem lists; and potentially, old lab results and diagnostic images.¹⁰³¹ The migration can be done by non-clinical staff, however, physicians may find it beneficial to enter the data themselves as it provides a renewed familiarity with accurate patient data.¹⁰³² It is recommended that practices plan to enter all essential data and “retire the paper chart” by a patient’s second post-implementation visit, with the goal of achieving nearly 100 percent migration by 6-9 months after implementation.^{1033,1034} It has been suggested that practices choose a “drop-dead” date for when the paper charts are no longer used, and that this date is communicated to all practice staff from day one of implementation.

IT consultants may be particularly helpful for small practices wishing to customize or update the EMR systems after implementation. One interviewee cited the example of new medications

arriving on the market. Practices will need to update areas such as formularies and cross-reactions.

Practices should be advised that the process is not complete after the EMR is implemented. It will be necessary to upgrade hardware and software periodically, and to train staff on new features. The market and community landscape is likely to change as well, and practices may have to adapt to maintain interoperability and connectivity with colleagues and business partners. In addition, as practices gain experience and comfort with the new EMR system, their desired functionalities and EMR system requirements may change and evolve over time. This may lead to implementation of additional modules or modifications to the existing system.

Throughout the implementation process, it is important for practices to celebrate small victories.¹⁰³⁵ Practices should hold regular meetings where staff have an open forum to discuss issues with the new system and associated processes, and share lessons learned and tips with the group.¹⁰³⁶ It may be possible to further streamline workflows and processes based on a process of continuous improvement after the EMR has been implemented. Practices should be encouraged to reach out to colleagues and the local health community and/or other online resources for help, guidance and reassurance.¹⁰³⁷

11.0 Conclusion

Estimates from the survey literature show adoption rates of 15-18 percent in the ambulatory environment, with adoption being positively related to practice size.^{1038,1039} In light of such low penetration rates, achieving the President's stated goal of providing an EMR to most Americans in ten years will require significant changes in the rate of adoption among physician practices. This change is especially critical given that approximately 75-80 percent of practices are small, with nine or fewer physicians.^{1040,1041,1042} Accelerating the pace of adoption requires a deeper understanding of the factors that significantly impact adoption decisions and the magnitude of their impact. Such an understanding is fundamental to programs or policies that seek to alter the timing and pace of adoption.

Based on an analysis of the literature and the findings from physician office site visits we have identified certain key economic and non-economic elements that influence adoption. These elements include:

- ▶ Physician preferences for income, patient safety/quality, and leisure
- ▶ Variations in EMR functionality
- ▶ EMR costs and benefits
- ▶ Role of human capital
- ▶ Role of uncertainty
- ▶ Importance of information

Our analysis revealed that physicians are motivated to adopt EMRs by both financial and non-financial factors. Physicians care about quality and patient safety in addition to their income and leisure. Income is a function of practice revenues and costs, and EMRs have the potential to alter income either through reduction in costs or through increases in revenue. Although the importance of the cost-benefit calculus in EMR adoption has been recognized in the literature, there are aspects of costs that have not been well characterized. For instance in addition to costs associated with acquisition, implementation, annual maintenance, and upgrades, we have found that the costs associated with product research and vendor selection have been underestimated and may be relevant to the adoption decision.

As discussed earlier in the report, the evidence from the literature on EMR costs and benefits is generally based on projection models rather than empirical measurement. Some evidence regarding the impact of EMRs on quality is contradictory. Gaps in the literature and ambiguous findings contribute to physician perceptions of uncertainty regarding net benefit. This uncertainty is compounded by the complexity of the technology and challenges in making judgments regarding the merits of any individual product. Other sources of uncertainty include concerns about technology obsolescence, vendor stability, and unresolved standards. Such uncertainty in

the setting of substantial costs seems to play a significant role in causing physicians to defer adoption. The survey literature supports this perspective. In these surveys physicians have cited excessive costs in relation to uncertain benefits, vendor instability, lack of standards, and weak evidence as barriers to adoption.^{1043,1044}

Given the level of uncertainty that physicians face with respect to EMR adoption, information plays a very important role in lowering uncertainty. Physicians obtain this information from a variety of sources including websites, conferences, and most importantly from peers. All the sites we interviewed visited other practices to gain first-hand knowledge of the EMR system they were considering. This is consistent with the technology and medical innovation diffusion literature which emphasizes the importance of peer networks in stimulating, or impeding, adoption. Another important factor that emerged during our site visits in particular is the importance of a physician champion with significant computer or EMR experience. This human capital can reduce the cost of information acquisition, ensure smooth implementation, and reduce uncertainty.

We have developed a microeconomic approach to technology adoption that captures the interrelationships among the elements discussed above. Estimation and validation of the framework requires data that are currently unavailable from published sources. As part of this study, we have developed a strategy to validate the proposed economic framework. In addition, we correlated findings from the survey literature to EMR costs and benefits. As stated previously, the survey literature has highlighted the significance of practice and physician characteristics such as size, specialty, location, and age in the EMR adoption decision. A closer examination of these factors reveals that they affect the costs and benefits for a given practice. For example, size can yield significant economies of scale and improved negotiating power with the vendors. Age could affect adoption because the time horizon over which older physicians incur costs and reap benefits is relatively limited, and therefore more senior physicians may view costs as excessively high relative to benefits. Similarly, specialty can affect costs and benefits through its impact on desired functionality, level of reimbursement, and learning effects from other technologies.

Although our framework and associated elements are based on the most robust studies currently in existence, we are aware that there are gaps and limitations associated with this literature. The first set of limitations relate to the survey literature.. These include the following:

- ▶ Non- standardized definitions of EMR, and EMR definitions are not correlated with different levels of functionality
- ▶ Emphasis on non-modifiable practice or physician characteristics such as size, location, specialty, age etc.

There is a lack of detailed and comprehensive data that correlates different levels of functionality with costs, benefits and financial characteristics of the practice as well as other factors such as access to capital.

There is also a lack of objective and robust evidence on the costs and benefits associated with EMR adoption. The cost-benefit literature is largely based on predictive models, expert opinion and extrapolation from other literature sources. At the time this study was conducted there was a single retrospectively designed evaluation of costs and benefits in a 14 small practices.¹⁰⁴⁵ Given the importance EMR costs and benefits to the EMR adoption decision, such a lack of evidence can increase physician uncertainty and result in physicians deferring adoption.

Appendices

Appendix A: Category of Functionality

Category of Functionality ¹⁰⁴⁶	
<ul style="list-style-type: none"> • Identify and maintain a patient record • Manage patient demographics • Manage problem list • Manage medication list • Manage allergy and adverse reaction list • Manage patient history • Summarize health record • Manage clinical documents and notes • Capture external clinical documents • Generate and record patient specific functions • Order medication • Order diagnostic tests • Manage order sets • Manage results • Manage consents and authorizations • Manage patient advance directives • Support for standard-care plans, guidelines, protocols • Capture variances from standard-care plans, guidelines, protocols • Support for drug interaction • Support for medication or immunization administration or supply • Support for non-medication ordering (referrals, care management) 	<ul style="list-style-type: none"> • Present alerts for disease management, preventive services, and wellness • Notifications and reminders for disease management, preventive services, and wellness • Clinical task assignment and routing • Inter-provider communication • Pharmacy communication • Provider demographics • Scheduling • Report generation • Health record output • Encounter management • Rules-driven financial and administrative coding assistance • Eligibility verification and determination of coverage • Manage practitioner/patient relationships • Clinical decision support system guidelines updates • Entity authorization • Enforcement of confidentiality • Data retention, availability, and destruction • Audit trail • Extraction of health record information • Concurrent use

Appendix B: Phone Interview Instrument

ALL PRACTICE QUESTIONS

Sections A and B will be asked of all practices, regardless of their adoption status.

PRACTICE DEMOGRAPHICS & STAFFING

A. Practice Demographics & Staffing – 20 minutes	
i. [Interviewer, document who you are interviewing for this section, and his/her role in this practice]	
1. How old is the practice i.e. how long have they been in business? [Interviewer – if the practice has been in more than one location, then note the length of time overall and in each location. Document each location, i.e. city and state]	
2. Is this a single or multi-specialty practice?	<input type="checkbox"/> Single <input type="checkbox"/> Multi-specialty
2a. Specify Specialty type(s):	
3. What is the total number of staff in the practice(s)?	__ __
3a. What is the breakdown by type of staff?	
A. Physicians [Indicate number and specialty] _____	
B. Nurses [Indicate number and type – LPN, RN, etc.] _____	
C. Physician Assistants?	<input type="checkbox"/> Yes, number: __ __ <input type="checkbox"/> No
D. Medical Technicians?	<input type="checkbox"/> Yes, number: __ __ <input type="checkbox"/> No
E. Lab Technicians?	<input type="checkbox"/> Yes, number: __ __ <input type="checkbox"/> No
F. Administrative/Office Staff [check if applicable]:	
	<input type="checkbox"/> Office Manager <input type="checkbox"/> Clerical Staff __ __
	<input type="checkbox"/> Receptionist __ __ <input type="checkbox"/> Billing Manager __ __
G. Other staff , specify _____	

4. What are the ages and tenure at this practice for each of the physicians?

Physician Name	Age	Tenure at this Practice	Tenure at Last Practice

5. Are you a for-profit practice? Yes (skip to #6) No

5a. Please describe your practice's not-for-profit structure:

6. Who owns the practice?

6a. Please describe the structure of the ownership:

BILLING & INCOME

The billing and income questions will be provided to the practices prior to the telephone interview.

B. Billing and Income – 30 minutes	
i. [Interviewer, document who you are interviewing for this section, and his/her role in this practice]	
1. What was the average pretax annual income for a physician in the practice last year?	
2. For the practice last year:	
2a. What were the annual total expenses?	
2b. What was the annual gross revenue?	
3. What are the major costs associated with operating your practice for:	
A. Labor – for non-physician staff (nurses, physician assistants, office manager, other admin staff). Please list by staff type: _____	
C. Non-labor – lease/rent amount: _____	
D. Non-labor – (Non-EMR related) Computers, hardware, software: _____	
E. Non-labor – other overhead, e.g. malpractice insurance: _____	
F. Other operating costs: _____	
4. What percent of your patients are:	
A. Medicare: __ __ B. Medicaid: __ __ C. Private insurance – HMO: __ __ 	
D. Private insurance – non-HMO: __ __ E. Pay out-of-pocket (e.g. self-insured): __ __ 	
F. Do you serve patients who are unable to pay? Approximately how many? _____	
5. How are you reimbursed [check all that apply]:	
<input type="checkbox"/> Fee-for-service	
<input type="checkbox"/> Full capitation – with prescriptions: <input type="checkbox"/> Yes <input type="checkbox"/> No	
<input type="checkbox"/> Partial capitation – with prescriptions: <input type="checkbox"/> Yes <input type="checkbox"/> No	
If Partial, give percent (%) of reimbursement: _____	
<input type="checkbox"/> Other, specify _____	
[If full or partial capitation are “no,” then skip to #6]	

5a. What services (i.e. diagnostic treatment services, immunizations, etc.) are covered under the capitated payment?

6. What is the size of your current patient population? |__|__|__|__|

7. How many patient visits do you have in one year? |__|__|__|__|__|

8. How many patient encounters does each physician have per day? |__|__|

9. How many days per week does each physician work? Please indicate the physicians that are full or part- time.

Physician Name	Days	Other Information (e.g. on call schedule)

QUESTIONS FOR PRACTICES THAT NEVER CONSIDERED ADOPTION

In addition to the questions in Chapter 2.0 (sections A and B), the following sections will be asked to practices who have never considered adoption of an EMR system.

EMR UNDERSTANDING

C. EMR Understanding – 20 minutes
i. [Interviewer, document who you are interviewing for this section, and his/her role in this practice]
1. How would you describe an EMR?
2. What is your experience with EMRs or CPOEs? [Interviewer, we may need to give other types of functionality as examples here]
3. Have you used an EMR in other (i.e. hospital) medical care settings?
4. What is your prior experience with computers?
5. Do you use a computer <input type="checkbox"/> Yes <input type="checkbox"/> No (skip to #3)
5a. How often do you use a computer, is it daily, weekly, or other? <input type="checkbox"/> Daily <input type="checkbox"/> Weekly <input type="checkbox"/> Other, specify _____
5b. For what types of tasks do you use a computer?
6. What kinds of technology do you currently use in your practice, for example do you have a practice management system, email, fax, scanners, web portal?
7. What methods do you use to communicate with patients in the practice? [Interviewer document any specific information and check off the applicable communication methods] <input type="checkbox"/> Telephone <input type="checkbox"/> Fax <input type="checkbox"/> Email <input type="checkbox"/> Web portal <input type="checkbox"/> Other, specify _____
8. How does the practice receive its lab and other test results?

PERCEIVED EMR BENEFITS & BARRIERS

D. EMR Benefits & Barriers – 20 minutes
i. [Interviewer, document who you are interviewing for this section, and his/her role in this practice]
1. What are some of the perceived benefits you associate with an EMR? [Interviewer, document conversation, and check if any of the factors below were mentioned. If not mentioned suggest these categories and solicit response] <input type="checkbox"/> Improve Patient safety <input type="checkbox"/> Improve Quality of Care (decision support; evidence based medicine) <input type="checkbox"/> Cost Reduction (labor/other) <input type="checkbox"/> Improvements in workflow processes <input type="checkbox"/> Revenue enhancement/charge capture <input type="checkbox"/> Differentiation in market place (have competitors adopted/not adopted; have patients requested) <input type="checkbox"/> Improvements in your quality of life – increased leisure time <input type="checkbox"/> Other, specify _____
2. Do you have colleagues who have adopted or considered adoption of an EMR with whom you have discussed EMR adoption? <input type="checkbox"/> Yes, specify _____ <input type="checkbox"/> No (skip to #3)
2a. Has this information affected your perceptions of the costs and benefits associated with an EMR? If so how?
3. Do you have any concerns about EMR that would prevent you from considering adoption in the future? If so which of these barriers are most significant? [Interviewer should capture response to open ended question and then probe the significance of the following factors if not mentioned] <input type="checkbox"/> Uncertain about the benefits of this technology because you have heard negative or conflicting reports from peers (or other sources – describe) <input type="checkbox"/> Difficult to assess the usefulness and value of this technology because it is so complex <input type="checkbox"/> Just don't have enough time to do the level of research that would make me/us feel comfortable making a purchase of this magnitude <input type="checkbox"/> Insufficient reliable information regarding the most desirable EMR functions to purchase <input type="checkbox"/> Concerns that technology currently on the market will soon be obsolete

- Concern that vendor may not be stable over time
- Concerned with high cost structure
- Concern that costs presented are underestimates of the actual costs you will incur
- Concerns regarding access to credit
- Concern regarding the potential loss of productivity both short and long-term
- Concerns with the lack of widely accepted standards
- Concerned with increased liability
- Other, specify _____

4. Do you think you may change your decision and adopt EMR in the future? What are the most important factors that may increase the likelihood of adoption by your practice?

[Interviewer, END OF INTERVIEW FOR THOSE NOT CONSIDERING ADOPTION]

QUESTIONS FOR PRACTICES THAT CONSIDERED ADOPTION OR HAVE ADOPTED

In addition to the questions in Chapter 2.0 (sections A and B), the following sections will be asked to practices that are considering adoption, have considered adoption but decided against, or have adopted an EMR system.

EMR UNDERSTANDING

E. EMR Understanding – 20 minutes
i. [Interviewer, document who you are interviewing for this section, and his/her role in this practice]
1. How would you describe an EMR?
2. What is your prior experience with computers?
3. What is your prior experience with EMRs or CPOEs? [Interviewer, we may need to give other types of functionality as examples here]
4. Do you use a computer? <input type="checkbox"/> Yes <input type="checkbox"/> No (skip to #3)
4a. How often do you use a computer, is it daily, weekly, or other? <input type="checkbox"/> Daily <input type="checkbox"/> Weekly <input type="checkbox"/> Other, specify _____
4b. For what types of tasks do you use a computer?
5. What kinds of technology do you currently use in your practice, for example do you have a practice management system, email, fax, scanners, web portal?
6. What methods do you use to communicate with patients in the practice? [Interviewer document any specific information and check off the applicable communication methods] <input type="checkbox"/> Telephone <input type="checkbox"/> Fax <input type="checkbox"/> Email <input type="checkbox"/> Web portal <input type="checkbox"/> Other, specify _____
7. How does the practice receive its lab and other test results?

EMR RESEARCH & DECISION-MAKING

F. EMR Research & Decision-Making – 45 minutes
i. [Interviewer, document who you are interviewing for this section, and his/her role in this practice]
1. Why and when did you begin investigating the purchase of EMRs?
2. Who initiated the process and who was/is responsible for the decision?
3. Can you describe the process you undertook or are undertaking to evaluate EMRs, for instance:
[Interviewer, offer the respondent questions 3a-3c as possible responses to this question]
3a. Did you obtain EMR information through review of the literature, through vendors, colleagues, etc.? Did you employ an outside consultant?
3b. Did you contact vendors? How did you choose which vendors to contact? How many did you contact?
3c. How easy was it to compare information presented by the vendors? What were some of the things you compared?
4. Did you use an RFP or any functional requirements to assist you in the evaluation?
5. Did you receive any assistance, either monetary, research support or other, from organizations, the government, regional health information networks? If yes, then describe _____
6. What were the resources, for example staff, time, money, expended in you evaluation process? Can you determine the total cost expended in this evaluation process including any consultant time?
[Interviewer, if dollar amount is not available then probe into the amount of staff time, type of staff that were involved. Also we should ask who was assigned to do the evaluation and research regarding the choice of vendor and technology, how much time they devoted to the effort, etc.]?
7. How long did it take you to complete your evaluation of EMRs?
8. [ADOPTERS ONLY] When you made the decision to purchase, how was this made, for example was there a deciding factor? Who was the primary decision maker? Was there a vote or consensus process? If so, who participated in the process?
9. [NON-ADOPTERS ONLY] Why did you decide to not adopt? How did you arrive at this decision?

10. What were the most significant challenges you faced in evaluating EMRs? Were they financial, legal, operational, and technical? Please describe.

11. [ADOPTERS ONLY] How did you overcome any of the barriers or challenges that you encountered?

12. [ADOPTERS ONLY] Are there any other local practices, or colleagues, using the system you chose?

Yes No (skip to H)

12a. [ADOPTERS ONLY] Was this important in your decision-making? Why?

13. [NON-ADOPTERS ONLY] Are there any other local practices, or colleagues, who are using the system you considered or are considering?

14. [NON-ADOPTERS ONLY] Do you think a government certification of an EMR would have affected or will affect your consideration of EMR adoption?

PERCEIVED EMR BENEFITS & BARRIERS

This section is only for the practices who considered but did not adopt an EMR system.

G. EMR Benefits & Barriers – 20 minutes [this section only for practices who have <u>not</u> adopted]	
i. [Interviewer, document who you are interviewing for this section, and his/her role in this practice]	
1. What did you perceive as some of the benefits of EMR adoption? [Interviewer, document conversation, and check if any of the factors below were mentioned. If not mentioned suggest these categories and solicit response.]	
<input type="checkbox"/> Improve Patient safety	
<input type="checkbox"/> Improve Quality of Care (decision support; evidence based medicine)	
<input type="checkbox"/> Cost Reduction (labor/other)	
<input type="checkbox"/> Improvements in work flow processes	
<input type="checkbox"/> Revenue enhancement/charge capture	
<input type="checkbox"/> Differentiation in market place (have competitors adopted/not adopted; have patients requested)	
<input type="checkbox"/> Improvements in your quality of life – increased leisure time	
<input type="checkbox"/> Other, specify _____	
2. Do you have colleagues who have adopted or considered adoption of EMR with whom you have discussed EMR adoption?	
<input type="checkbox"/> Yes, specify _____	<input type="checkbox"/> No (skip to #3)
2a. Has this information affected your perceptions of the costs and benefits associated with an EMR? If so how?	
3. What concerns did you have about EMRs that prevented you from adoption? Which of these barriers were most significant? [Interviewer should capture response to open ended question and then probe the significance of the following factors if not mentioned]	
<input type="checkbox"/> Uncertain about the benefits of this technology because you have heard negative or conflicting reports from peers (or other sources – describe)	
<input type="checkbox"/> Difficult to assess the usefulness and value of this technology because it is so complex	
<input type="checkbox"/> Just don't have enough time to do the level of research that would make me/us feel comfortable making a purchase of this magnitude	
<input type="checkbox"/> Insufficient reliable information regarding the most desirable EMR functions to purchase	
<input type="checkbox"/> Concerns that technology currently on the market will soon be obsolete	

- Concern that vendor may not be stable over time
- Concerned with the high costs structure
- Concern that costs presented are underestimates of the actual costs you will incur
- Concerns regarding access to credit
- Concern regarding the potential the loss of productivity both short and long-term
- Concerns with the lack of widely accepted standards
- Concerned with increased liability
- Other, specify _____

4. Do you think you may reverse your decision? If so, what would be the most important in prompting you to change your decision to not adopt at this time?

QUESTIONS FOR EMR ADOPTERS ONLY

In addition to all the sections in Chapter 2.0 (sections A and B), chapters 4.1 (section E) and 4.2 (section F), the following sections will be asked of EMR adopters during the telephone interview to the extent possible. Some of these questions may be pursued at the in-person site visits.

EMR PURCHASE & IMPLEMENTATION

H. EMR Purchase & Implementation – 30 minutes	
i.	[Interviewer, document who you are interviewing for this section, and his/her role in this practice]
1.	What vendor did you buy your EMR from?
1a.	Do you know what version it is?
2.	Were there any negotiating factors used to successfully reduce your purchase price? [Interviewer, for example, did the practice serve as a beta site, agree to future purchases, etc.]
3.	What other vendors did you consider purchasing from?
4.	What kinds of general functionality did you initially want?
5.	What functions did you choose to <u>not</u> include? Why?
6.	What functionalities did you purchase?
7.	Can you provide us with information on the costs of the Hardware: Software: Training: Implementation:
8.	In the procurement/implementation process, what functionalities did you discover you wanted but did not initially purchase? Are there functionalities/capabilities that you are awaiting in future upgrades?
9.	How was your purchase financed?
10.	Can you tell us the process you went through for implementing the system? Did you have a time schedule with the vendor? Were there any training sessions by the vendor? Did you retain an independent IT consultant to assist with training?
11.	Did you encounter any implementation hurdles? If so, how did you overcome these?
12.	Was the cost of implementation comparable to what you expected? If not, please explain.
13.	Are you pleased with the system you have implemented? If not, why?

EMR BENEFITS & BARRIERS

I. EMR Benefits & Barriers – 30 minutes

i. [Interviewer, document who you are interviewing for this section, and the relationship in this practice]

1. **What are some of the benefits that you have experienced in having an EMR?** [Interviewer, document conversation, and check if any of the factors below were mentioned. If not mentioned, ask the respondent if this was considered]

- Improve Patient safety
- Improve Quality of Care (decision support; evidence based medicine)
- Cost Reduction (labor/other)
- Improvements in work flow processes
- Revenue enhancement/charge capture
- Differentiation in market place (have competitors adopted/not adopted; have patients requested)
- Improvements in your quality of life – increased leisure time
- Other, specify _____

2. **What were the factors that were most significant in influencing your decision to adopt an EMR?**

3. **Do you have colleagues who have adopted EMR (or considered it) with whom you have discussed EMR adoption?**

- Yes, specify; _____ No (skip to #4)

3a. **Did this information affect your decision to adopt or delay EMR adoption?**

- Yes, specify _____ No

4. **What are some of the challenges you experienced with adoption?**

- Technology, specify _____
- Costs, specify _____
- Productivity, specify _____
- Other _____

5a. **How are you handling these challenges?** _____

Appendix C: In-Person Site Visit Instrument

QUESTIONS FOR ADOPTERS

[These questions will be asked of practices who have adopted.]

PRELIMINARY QUESTIONS

A. Preliminary Questions	
i.	[Interviewer, document who you are interviewing for this section, and his/her role in this practice]
1.	The data collected during this conversation will be used to inform a final report which will eventually become publicly disseminated. May we cite you and your staff's responses as part of this report, or would you prefer to remain anonymous?
2.	At this time we would like to address some questions regarding EMR Purchase and Implementation that we did not have the chance to discuss with you when last we spoke over the phone. [Look at Phone Interview results for missed questions or to gain further clarification of phone responses]

EMR SYSTEM CHARACTERISTICS

A. EMR System Characteristics	
i.	[Interviewer, document who you are interviewing for this section, and his/her role in this practice]
1.	Have all physicians in the practice adopted the EMR or have some continued to use paper only?
1a.	What reasons do the non-users give for their decision?
1b.	Do the non-users contribute to problems in the office workflows because they are not using the EMR?
2.	Among physicians using the system, are all physicians using similar levels of functionality or is there significant variability? For example, some physicians use the documentation function and some don't?
2a.	If there is significant variability, which physicians have embraced which functionalities and why?
3.	Before you purchased and implemented your EMR, what types of functionalities did you consider or examine in your decision process?
4.	What kinds of functionality did you purchase and how usable are they in comparison to the use of paper? [Interviewer – Prompt participant with the categories in the tables below and complete tables.]

EMR Function – DOCUMENTATION								
Function	Question: Choose the ease of use for each function based on the scale provided?	Was this a desired function?	Rank Ease of Use Based on Scale of 1-5					Not Applicable
			1. Very Poor – This EMR function is much less efficient than previous paper charting process	2. Poor – This EMR function is somewhat less efficient to use than previous paper process	3. Adequate – This EMR function is comparable to the previous paper process but no better	4. Good – This EMR function is more efficient than previous paper process	5. Very Good – This EMR function is much more efficient than previous paper process	
Text	<input type="checkbox"/> Unstructured	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Structured/ Template	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Structured w/ categories	<input type="checkbox"/> Yes						
Data Entry	<input type="checkbox"/> Typed	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Dictation	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Voice recognition	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Handwriting recognition	<input type="checkbox"/> Yes						
Alerts	<input type="checkbox"/> None	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Basic (e.g. preventive service reminders)	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Advanced (e.g. clinical guidelines)	<input type="checkbox"/> Yes						
Reports	Specify _____	<input type="checkbox"/> Yes						

EMR Function – RESULTS VIEWING								
Function	Question: Choose the ease of use for each function based on the scale provided?	Was this a desired function?	Rank Ease of Use Based on Scale of 1-5					Not Applicable
			1. Very Poor – This EMR function is much less efficient than previous paper charting process	2. Poor – This EMR function is somewhat less efficient to use than previous paper process	3. Adequate – This EMR function is comparable to the previous paper process but no better	4. Good – This EMR function is more efficient than previous paper process	5. Very Good – This EMR function is much more efficient than previous paper process	
Type	<input type="checkbox"/> Lab Results	<input type="checkbox"/> Yes						
	<input type="checkbox"/> X-ray Results	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Image viewing	<input type="checkbox"/> Yes						
Alerts	<input type="checkbox"/> None	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Basic (e.g. reminders with critical values)	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Advanced	<input type="checkbox"/> Yes						
Communication	<input type="checkbox"/> Fax only	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Email & Fax	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Intra-system	<input type="checkbox"/> Yes						

EMR Function – RESULTS VIEWING							
	<input type="checkbox"/> External to lab How many labs?	<input type="checkbox"/> Yes					
Reports	Specify_____	<input type="checkbox"/> Yes					

EMR Function – MEDICATION ORDERING								
Function	Question: Choose the ease of use for each function based on the scale provided?	Was this a desired function?	Rank Ease of Use Based on Scale of 1-5					Not Applicable
			1. Very Poor – This EMR function is much less efficient than previous paper charting process	2. Poor – This EMR function is somewhat less efficient to use than previous paper process	3. Adequate – This EMR function is comparable to the previous paper process but no better	4. Good – This EMR function is more efficient than previous paper process	5. Very Good – This EMR function is much more efficient than previous paper process	
Text	<input type="checkbox"/> Unstructured	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Structured/ Template	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Structured w/ categories	<input type="checkbox"/> Yes						
Data Entry	<input type="checkbox"/> Typed	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Dictation	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Voice recognition	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Handwriting recognition	<input type="checkbox"/> Yes						
Alerts	<input type="checkbox"/> None	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Basic with reminders	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Advanced	<input type="checkbox"/> Yes						
Checks	<input type="checkbox"/> None	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Allergy & interaction	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Allergy, interaction, & alternative drug suggestions	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Available formulary	<input type="checkbox"/> Yes						
Communication	<input type="checkbox"/> Print for patient	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Print & fax	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Pharmacy connection – one way	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Pharmacy connection – two way	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Multiple pharmacy connections	<input type="checkbox"/> Yes						

EMR Function – TEST ORDERING								
Function	Question: Choose the ease of use for each function based on the scale provided?	Was this a desired function?	Rank Ease of Use Based on Scale of 1-5					Not Applicable
			1. Very Poor – This EMR function is much less efficient than previous paper charting process	2. Poor – This EMR function is somewhat less efficient to use than previous paper process	3. Adequate – This EMR function is comparable to the previous paper process but no better	4. Good – This EMR function is more efficient than previous paper process	5. Very Good – This EMR function is much more efficient than previous paper process	
Text	<input type="checkbox"/> Unstructured	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Structured/ Template	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Structured w/ categories	<input type="checkbox"/> Yes						
Alerts	<input type="checkbox"/> None	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Basic (e.g. reminders with critical values)	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Advanced	<input type="checkbox"/> Yes						
Communication	<input type="checkbox"/> Fax only	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Email & Fax	<input type="checkbox"/> Yes						
	<input type="checkbox"/> Intra-system	<input type="checkbox"/> Yes						
	<input type="checkbox"/> External to lab How many labs?	<input type="checkbox"/> Yes						

A. EMR System Characteristics (contd).
5. What functionalities were bundled together and sold to you as a unit?
6. Was the product that you purchased interoperable with your existing software or systems? [K-1]
7. Was the product that you purchased interoperable with existing systems that your local labs, pharmacies or peer practices use (practices that you share patients with)? [K-1]
8. Did you purchase a practice management software in conjunction with your EMR?
9. Is your EMR integrated with your practice management software?
10. What functionalities does your practice management system have? (If not already addressed)
11. Has the system you purchased required significant customization? If so, in what way?

COST IMPACTS ASSOCIATED WITH EMR ADOPTION

A. Costs Related to Acquisition	
i.	[Interviewer, document who you are interviewing for this section, and his/her role in this practice]
1.	In implementing your system, what costs related to the purchase or configuration of the EMR did you experience?
1a.	Please specify costs with respect to the following categories of acquisition costs:
•	Hardware
•	Software
•	Software training & installation
•	Workflow redesign, training, & paper-electronic chart conversion
•	Productivity loss during implementation
•	Other implementation costs
•	Technical/network system support
2.	Were implementation costs higher or lower than expected? By what percentage?
B. Annual Costs of EMR Adoption	
1.	In implementing your system, what recurring and annual costs have you experienced?
1a.	Please specify costs with respect to the following categories of annual costs:
•	Software maintenance & support
•	Hardware replacement
•	Internal IS/external IS contractors
•	Other ongoing costs
D. Impact of EMR on Operating and Administrative Costs	
1.	Has your practice experienced a reduction in administrative and other operating costs due to adoption:
	a. Malpractice insurance rates:
	b. Non-physician labor costs – Describe by type of labor (LPN, Office manager etc.) and how much.
	c. Paper Storage costs
	d. Paper supply savings
	e. Transcription savings (if FTE use for transcription has reduced):
	e. Personnel savings (excl. transcription savings, if there is a reduction in FTEs):

ASSOCIATED BENEFITS

A. Benefits Impacting Workflow Efficiency	
i.	[Interviewer will pose questions related to workflow efficiency if there was a change in time to perform various tasks in addition to or in place of actual reduction in costs. Interviewer, document who you are interviewing for this section, and his/her role in this practice]
1.	Has the implementation of the EMR significantly affected the workflow processes of the staff and the time to complete various tasks in your office? Please respond to how the implementation has affected the following workflow areas:
	Chart pulls:
	Transcription:
	Clinical Documentation:
	Reporting processes for drug refill and lab results:
	Others:
B. Benefits Impacting Revenue Cycle	
1.	Do you think that the use of the EMR has enhanced your practice's ability to collect revenue? [Interviewer: ask participant if they have enhanced their revenue due to the following reasons]
	Reduction in billing errors:
	Improved charge capture:
	Increased revenue from increased patient or visit volume:
	Increased coding levels:
	Reduced days in receivables:
	Regained lost charges:
	Others – Specify:
C. Clinical and Safety Benefits	
1.	Has the use of the EMR affected clinical utilization in the following areas? [Interviewer: ask participant if they have experienced utilization in the categories below:]
	Drug savings (including use of generics):
	Reduced radiology use:
	Reduced laboratory use:
	Drug Utilization:
	Others – Specify:
2.	Has the use of the EMR improved patient safety in the practice, specifically with respect to a reduction in adverse drug events (ADEs)?

<p>3. Has the adoption of EMR improved your ability to provide effective care to your patients through the following:</p> <p>3a. Adherence with evidence-based guidelines:</p> <p>3b. Improved access to patient information :</p>
<p>4. Have any of these benefits accrued directly to you? If yes, can you specify the type and magnitude of these benefits.</p>
<p style="text-align: center;">D. Benefits Impacting Quality of Life for Practice</p>
<p>1. Have physicians found they have more leisure time since implementing the EMR? If yes, how and by how much?</p>
<p>2. Has the EMR improved leisure time for your staff?</p>
<p>3. Do you think that EMR has impacted employee satisfaction or retention? How so? [H]</p>
<p style="text-align: center;">E. Benefits Impacting Patient Service</p>
<p>1. Do you think that the use of the EMR has impacted patient experience in your practice? [Interviewer will pose the following questions if answer is in the affirmative.]</p>
<p>2. Do you think that the EMR has enabled you to provide patients with improved access to their medical information? If yes, describe.</p>
<p>3. Do you think that the use of the EMR has improved patient satisfaction? [H]</p>
<p>4. Have wait times for patients waiting to be seen decreased? By what estimated amount? [H-3]</p>
<p>5. Did the time you spend communicating with patients change? By what estimated amount? [H-4]</p>
<p>6. Have you added web tools for patients perhaps on scheduling, email, etc?</p>
<p>7. Others – Specify.</p>

OTHER POST-IMPLEMENTATION OBSERVATIONS

<p style="text-align: center;">A. Other Observations</p>
<p>1. Are you satisfied with the EMR product that you have purchased? Did it Exceed, Meet, or Fall Short of your expectations?</p>
<p>1a. Please explain.</p>
<p>2. What are key lessons learned related to EMR adoption and use that would be useful to other practices?</p>
<p>3. What do you think needs to be done and by whom to accelerate adoption of EMRs in small practice settings?</p>

Endnotes

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