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for Planning and Evaluation (ASPE)

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

Executive Summary - Draft

September 30, 2006

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Exhibits

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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:

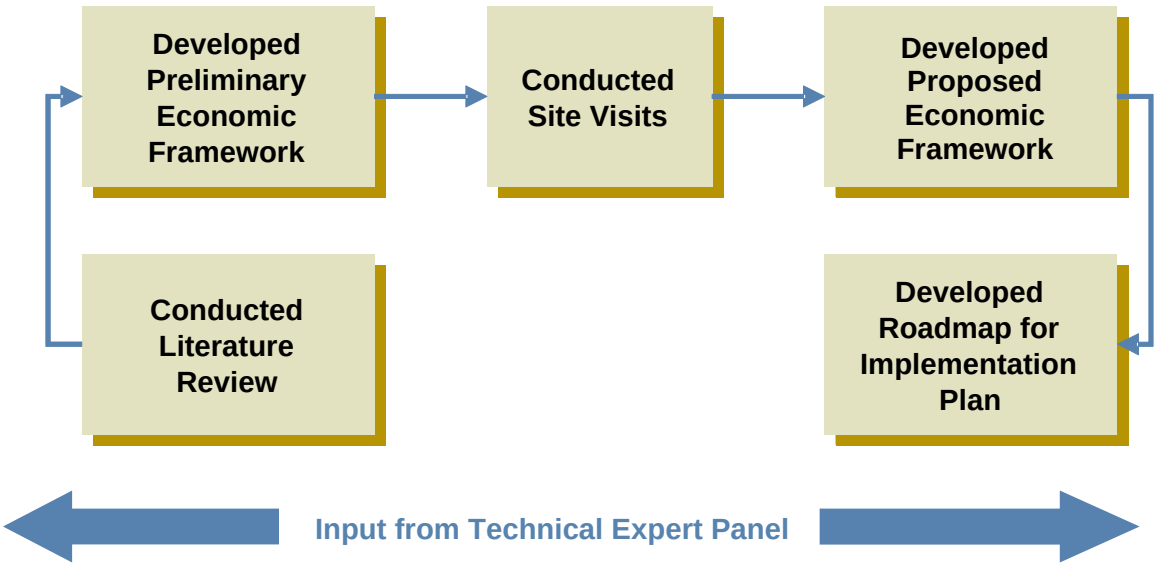
- Understanding the factors that influence EMR adoption in small practices
- Developing a microeconomic framework that incorporates these factors.

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.

Exhibit 1. Study Methodology



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 (H*i*MSS), 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. Evans[24], Mullett[25], Potts[26], and Fortescue[27] 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] Koppel[29] 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]

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,[126] Gans refers to the lack of capital resources,[127] the AAFP survey highlights affordability,[128] and the MRI survey describes EHR cost and lack of funding.[129] 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.[130]

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.[131] Perceived costs related to choosing an EMR were therefore often expressed in terms of time.[132,133] 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.[134,135] 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.[136,137]

Uncertainty regarding the costs and benefits of a technology can be a barrier to adoption.[138,139,140] 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."[141,142,143] 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.

Exhibit 4. Summary of Physician Perceptions of EMR Adoption Barriers

Audet, et al.[144]		Gans, et al.[145]		
Barrier	Percent	Barrier	Mean Rating: Practice w/ EHR	Mean Rating: 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 time	39.0	Lack of capital resources to invest in an EHR	3.31	3.58
Maintenance costs	37.0			
Lack of evidence of effectiveness	26.0	Concern about physicians' ability to use EHR	3.18	3.40
Privacy concerns	21.0	Concern about loss of productivity	3.04	3.24
Lack of training	16.0	Inability to evaluate, compare, select EHR	2.60	2.86

AAFP, 2005 EHR Survey[146]				Medical Records Institute[147]		
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
				Lack of support	37.2	35.4
Data entry cumbersome		+		EHR solutions that are fragmented	30.2	34.1
				Creating a migration plan	29.2	27.6
Risk of vendor going out of business		+		Meeting technical/clinical requirements	27.3	27.3
Lack of time		+				
Lack of expertise in selection		+		Inadequate health care information standards	22.9	27.3
Partner acceptance		+		Difficulty in building a strong business case	21.9	24.7
Complex contracts	+					
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[148]	
• High cost and uncertain benefits	• Inadequate support
• High initial physician time costs	• Inadequate data exchange with other systems
• Technology — poor usability	• Lack of incentives
• Difficult complementary (workflow) changes	• Physician attitudes

Legend: + Positive correlation, with no statistical significance

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 $z_1, \ldots, z_n$ 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:

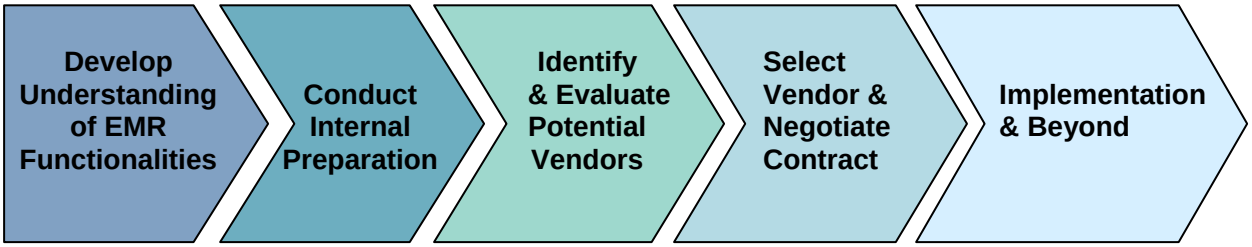
- Phase One involves evolution of the framework into a model through detailed mathematical specification.
- Phase Two entails collection of data that can be used to validate the model.
- Phase Three involves model estimation and validation.

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



Develop Understanding of EMR Functionalities	Conduct Internal Preparation	Identify & Evaluate Potential Vendors	Select Vendor & Negotiate Contract	Implementation & Beyond
▸ Gain familiarity with common EMR terms ▸ Explore functionalities defined by IOM, CCHIT and others ▸ Understand functionality levels and associated benefits	▸ Conduct internal assessment to describe baseline ▸ Plan for budget and strategy alignment ▸ Map capabilities to goals and requirements ▸ Consider using assessment tools (e.g., checklists, RFPs)	▸ Research and prioritize vendors based on ratings, compatibility, history with small practices, longevity and other factors ▸ Test-drive top 3-4 choices for hands-on experience ▸ Consult with colleagues and conduct site visits	▸ Contract should explicitly state: type, term, products & services included, current & future costs, vendor role & time commitment and other contingencies ▸ Consider hiring IT consultant or software contracts lawyer ▸ Develop timeline for implementation	▸ Train and troubleshoot before going live ▸ Transition from paper to electronic records ▸ Develop historical data migration plan ▸ The process is not over: the landscape is dynamic, and needs will evolve ▸ Practices should celebrate small victories and foster open communication to share lessons within the practice and the community

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.

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