PAYER-MIX AND THE ADOPTION OF HEALTH INFORMATION TECHNOLOGIES

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By

Corinne Elizabeth Vosmer, B.A.

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Many thanks,
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PAYER-MIX AND THE ADOPTION OF HEALTH INFORMATION TECHNOLOGIES

Corinne Elizabeth Vosmer, B.A.

Thesis Advisor: Melissa Favreault, Ph.D.

ABSTRACT

This paper investigates the influence of payer-mix on the presence and adoption of clinical health information technology (HIT) in health care systems. With growing concerns about the safety and rising cost of health care in the United States, an understanding of factors relating to the adoption of cost and outcome improving technologies can inform important policy decisions that have the potential to enhance the delivery of health care services. Results from this project provide some evidence that payer-mix has a statistically significant impact on whether health care systems have clinical HIT and if they choose to adopt these technologies. Revenue from managed care sources has the greatest magnitude and statistical significance among different payers. On average, managed care revenue tends to increase the probability of the presence or adoption of clinical IT applications in a health care system. Managed care systems, which are more 'closed' may be better able to internalize the benefits of HIT investment and thus be more likely to use these technologies.

Introduction

We are facing a health care crisis in America.

A 2000 report, titled *To Err is Human: Building a Safer Health Care System,* estimates that as many as 98,000 Americans die each year from preventable medical errors (IOM, 2000). These serious gaps in quality persist despite an annual price tag of over $1.7 trillion for health care services (RAND, 2005). As a share of the economy, health care has risen from 7.2% of GDP in 1965 to over 16% of GDP today, and is projected to grow to 20% of GDP just 10 years from now (Borger et al, 2006).

Private industry and the Federal government are increasingly looking to the implementation of health information technology (HIT) as a mechanism through which to transform health care and improve the safety and efficacy of medical treatments. One 2005 study estimates that the adoption of electronic medical records could save more than $813 billion annually; another states that computerized medication order systems could eliminate around 200,000 potentially fatal adverse drug events each year (Hillestad, 2005; RAND, 2005).

Yet, given all of the well documented benefits of information technology in health care, the adoption of such systems is lower than we would expect. One form of HIT, the electronic medical record (EMR), has experienced steady but relatively limited diffusion in the United States, despite the high level of sophistication this tool has achieved in its 30- year history (Audet et al, 2004). The 12th Annual Health Information Management Systems Society (HIMSS) Leadership Survey conducted in 2001 indicates that 13% of health care organizations utilize a fully operational EMR system, climbing one percentage point from the previous year (Ondo, Wagner, Gale; 2002). The Institute of Medicine report, *Crossing the Quality Chasm*, states that "IT has barely touched patient care" (IOM, 2001).

In order to develop appropriate and effective policies to incentivize the adoption of HIT, it is important to understand the barriers to implementation of these technologies. Most often, capital cost is cited as an impediment to adoption of medical information technology. However, the story grows more complicated in the framework of the complex American health care system, where third parties pay for the majority of health care services. One commentator has noted: "most HIT-enabled savings go to insurers and patients, while most adoption and care improvement costs are borne by providers" (Ferman, 2006). Thus, it would seem that the incentives to adopt health information technology are misaligned.

By exploring the influence of payer-mix on a health care organization's decision to implement IT systems, we may reach a deeper understanding of the interplay between complex health care financing systems and the adoption of capital intensive IT investments. Payer-mix refers to the proportion of revenues an organization receives from payers such as Medicare, Medicaid, managed care plans, and private insurance. Different payers impose different financial-behavioral incentives through their reimbursement systems.

Through a better understanding of the nuanced incentives compelled by different payers, we may better inform how policies can be used to stimulate the adoption of technologies that have the power to save costs and preserve life.

BACKGROUND

Hardly a day goes by without hearing something in the national media about the failures of the United States health care system. Magazine covers, newspaper exposés, and public television series consistently broadcast information about rising health care costs, the growing proportion of the uninsured, concerns about the safety of health care, and the impact of the aging population on the sustainability of Medicare.

Data support these accounts. As a share of the economy, health care has risen from 7.2% of GDP in 1965 to over 16% of GDP today, and is projected to grow to 20% of GDP just 10 years from now (Borger et al, 2006). The United States spends more on health care than any other industrialized country, yet life expectancy in the United States is below the OECD average and the nation fares poorly on some key indicators of health such as infant mortality (OECD, 2006). With regards to health care quality, a 2003 study finds that United States physicians deliver recommended care only about half of the time (McGlynn et al, 2003). Increasingly, thought leaders are looking to the widespread implementation of health information technology as a tool to transform the health care industry.

A growing body of evidence suggests that well-designed IT systems have the potential to transform health care. A 2005 study by Hillestad and colleagues uses estimates of IT-enabled productivity gains in other industries to predict that HIT could reduce annual health care spending by $346-$813 billion. Furthermore, this study estimates that one type of HIT, computerized physician order entry (CPOE) could eliminate as many as 200,000 adverse drug events each year (Hillestad et al, 2005). This is a particularly salient finding in light of a 2000 report from the Institute of Medicine estimating that as many as 98,000 Americans die each year from preventable medical errors.

HIT has gained traction as a critical component of the Federal health agenda. In 2004, President Bush called for "widespread adoption of electronic health records (EHRs) within 10 years so that health information will follow patients throughout their care in a seamless and secure manner" (White House, 2004). Resources are also following this national attention to HIT; in fiscal year 2004, HHS provided about $228 million on a broad range of initiatives to develop, promote, and research the adoption of HIT (GAO, 2004).

However, the adoption of HIT systems has not been as pervasive as the positive evidence would suggest. A 2005 RAND study estimates that approximately 32% of hospitals have electronic medical record (EMR) systems, but just about 5% of hospitals have robust integrated information technology systems with clinical applications. The United States trails several other countries in the use of EMR systems (Hillestad et al, 2005). Audet et al note that EHR adoption in both the United Kingdom and Sweden is supported by government subsidies and adoption rates are 58% and 90% respectively (2004). In the context of this research, it is also interesting to note that these countries also have single-payer systems in contrast to the multiple-payer system in the United States. Under a single-payer system, the incentives to adopt HIT may be better aligned.

A number of observers have commented that there is a misalignment of incentives that limit the adoption of HIT: "Medicare would receive about $23 billion in potential savings each year [from

HIT integration], and private payers would receive $31 billion per year. Both have a strong incentive to encourage adoption. However, providers face limited incentives to purchase EMRs because their investment typically translates into revenue losses for them and health care spending savings for payers" (Hillestad et al, 2005).

The purpose of the present paper is to explore characteristics of hospital systems that are associated with the adoption of HIT, with a focus on payer-mix. The hospital system is the unit of analysis in this research. Hospital systems are parent organizations with more than one health care facility. The rationale for this approach is that the business decision to invest in HIT likely resides in upper organizational levels rather than in individual facilities themselves (RAND, 2005).

Also addressed in this research is the potential influence of medical malpractice premiums on a hospital's decision to adopt health information technologies. HIT is often touted as a tool to reduce medical errors and to the extent that health care organizations are engaging in risk-management to prevent medical errors, then patient-safety oriented HIT may be implemented as a means to reduce malpractice risk.

LITERATURE REVIEW

PREVIOUS FINDINGS

There exists a handful of published research that uses HIT adoption as a dependent variable to explore hospital characteristics that are associated with the implementation of these technologies. The most comprehensive of these studies is a 2005 paper by Fonkych and Taylor at RAND which uses the HIMSS-Dorenfest database. A 2002 presentation paper by Wang and Wan also uses the HIMSS-Dorenfest database to identify correlates of HIT adoption. Papers by Parente and Van Horn (2003) and Borzekowski (2002) offer additional specific research questions and will be described separately.

OVERVIEW

There is broad consensus that hospital size is positively correlated with the adoption of HIT systems. Borzekowski postulates that health information systems exhibit increasing returns to scale and, thus, larger organizations will face economies of scale in HIT adoption (2002). In results from a hazard model, he finds that the impact of hospital size is positive for the adoption of a range of IT applications, ranging from administrative to clinical; these results are significant at the 95% confidence level (Borzekowski, 2002).

Results from the RAND study support this finding; they estimate a statistically significant positive correlation between clinical IT applications and various measures of hospital size, including: staffed beds, full-time equivalent personnel, and patient admissions (2005). Wang and Wan use staffed beds as their measure of hospital size and find a positive and statistically significant result at the 99%confidence level (2002). They also use complexity of services as a measure for hospital size and find a positive and significant result at the 99% confidence level (2002).

The RAND study states that “the real leaders in the HIT-adoption process are academic and pediatric hospitals” (2005). Authors find that the presence of HIT systems in academic hospitals is about double that in non-academic institutions; however, this relationship may be driven by the larger size of academic hospitals rather than their teaching orientation alone (RAND, 2005).

Anecdotal evidence as well as published research from RAND (2005), Borzekowski (2002), and Culler et al (2006) points to geographic location as a determinant in the adoption of HIT. In particular, rural hospitals are less likely to adopt HIT. Factors that may contribute to lower implementation rates in rural areas include: less access to capital, lower availability of staff with information technology expertise, and a smaller scope of services provided.

Cutler and McClellan identify six factors that may influence technology diffusion in health care that include: organizational factors within hospitals, the insurance environment in which technology is reimbursed, public policy regulating new technology, malpractice concerns, competitive or cooperative interactions among providers, and demographic composition (1996). The authors find that insurance variables have among the largest quantitative effect on technological diffusion (Cutler and McClellan, 1996).

Hospital services under Medicare are reimbursed according to the prospective payment system (PPS). With prospective payment, claims are based on a fixed schedule of diagnosis related groups (DRGs), meaning that a hospital will be reimbursed based on patient diagnosis rather than actual costs incurred to provide treatment. Under such a structure, hospitals are incentivized to keep costs low so they can retain the payment difference between the reimbursement and treatment cost. If treatment costs are above the specified payment for that DRG, the hospital faces the risk of losing money.

Traditional commercial insurance is reimbursed under the fee-for-service system. Under this arrangement, providers are reimbursed for the costs incurred to treat the patient. Providers face different incentives under these two payment mechanisms because of the presence of risk-sharing in the PPS model.

Managed care is a broad term that describes a variety of organizations and is often used to express the organization of doctors, hospitals, and other providers into groups in order to enhance the quality and cost-effectiveness of health care. Examples of managed care plans are health maintenance organizations (HMOs) and preferred provider organizations (PPOs). Although there are some differences between managed care plans--for example, whether providers are employees of the plan--these plans share the characteristics of capitation and selective contracting, where payers negotiate prices and contract selectively with providers and hospitals.

Shortell and colleagues (1994) view a key characteristic of managed care as the delivery of care to a defined number of enrollees at a capitated or fixed rate per member per month. They describe that as a result of this structure:

> Cost centers such as hospitals, physician groups, clinics, and nursing homes must be managed under a fixed budget. Under traditional FFS plans, cost centers generate revenue, so more volume means more profit. Under managed care, more volume means less profit.

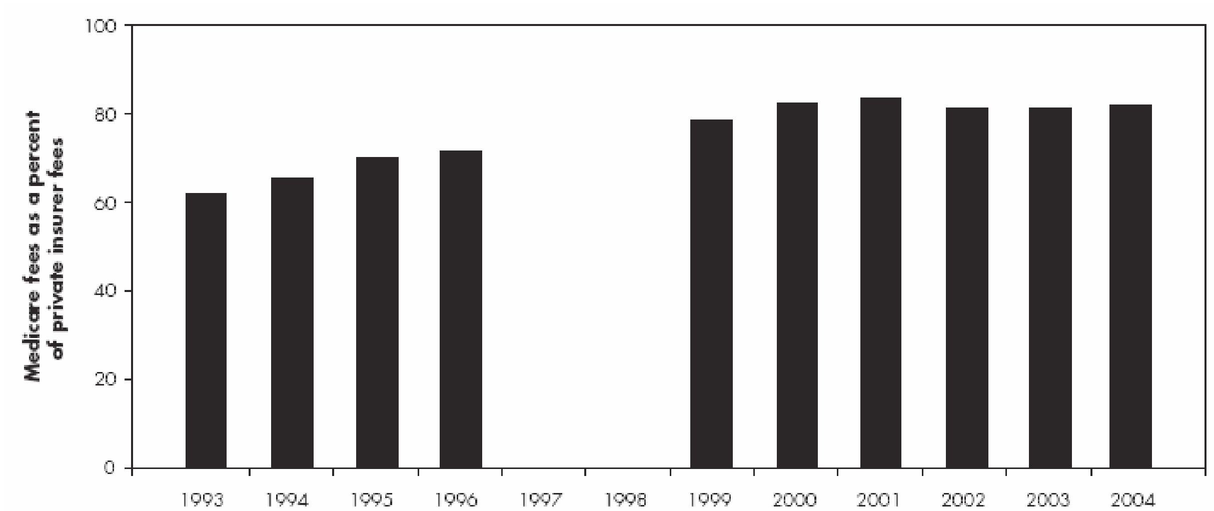
Research pertaining to insurance reimbursement and incentives to adopt HIT is limited and ambiguous. RAND researchers find that hospitals receiving a high proportion of claims paid by

Medicare are less likely to have clinical IT systems (2005). They also find that the magnitude of correlation is statistically significant and comparable to the effect of hospital size (RAND, 2005).

However, a 2002 paper by Borzekowski which takes advantage of the implementation of PPS as a natural experiment, finds that additional cost-sharing in the Medicare system spurred the adoption of HIT in hospitals with large a large proportion of Medicare patients. This study uses data from 1982 and 1984. The RAND paper uses 2004 data. It appears that the incentives or drivers for the adoption of HIT somehow changed course during this period. Another possibility is that organizational perceptions about the effectiveness or HIT systems may have changed.

The 20-year space between these data witnessed momentous change in computing which made information technology cheaper, more powerful, and easier to use. Thus, we can imagine that the decision to adopt HIT involved different factors in these two time periods. Adopters in the 1980s were at the innovative "technology trigger" stage of the Gartner "Health IT Hype Cycle," which is a graphic representation of the maturity, adoption and business application of specific technologies (Rishel and Hieb, 2005). However, by 2004, organizations choosing to adopt faced more mature and stable product choices. This does not seem to explain the association between Medicare revenue and adoption; one would expect organizations to be more likely to adopt more mature technologies as this may indicate the potential for positive return-on-investment.

Exhibit 1 illustrates that over the past decade, the difference between Medicare payment rates and private insurer reimbursements has narrowed and remained relatively stable in recent years (MedPAC, 2006). 2004 Medicare reimbursements were 83% of rates from private insurers.



Source: MedPAC (2006), Table 2B-2

Exhibit 1: Ratio of Medicare to Private Reimbursement Rates

Borzekowski considers HIT systems a cost-saving technology; as a result, organizations facing capitations or a cost-sharing reimbursement structure may induce hospitals to adopt HIT as a vehicle to reduce cost (Borzekowski, 2002). However, a large initial capital investment as well as on-going maintenance costs may make the decision for some systems to adopt prohibitive.

A 2005 paper by Selder indicates that a shift from fee-for-service to capitation (e.g., HMO-style payments) slows the take-up of a broad range of health technologies, but distinctions between diagnostic, treatment, and process-oriented technologies such as HIT are not made. This finding may inform why restrictive reimbursement models may suppress adoption and lend support to the RAND finding of a negative association between Medicare revenue and HIT adoption.

The RAND 2005 study finds an ambiguous relationship between HIT adoption and a hospital's share of Medicaid patients. The authors note that the strong tendency of academic hospitals (which are more likely to be large) to treat Medicaid patients partially explains the association, as does the managed-care orientation of the Medicaid population (RAND, 2005).

Another factor that may impact adoption is the perceived or real "learning curve" or time period required to reap full benefits of implementation. A qualitative study of small physician offices by Miller and colleagues describes that it can take several months or even years to fully learn HIT software (2003). The authors also find that users of the same EMR system can experience a wide range of benefits and time costs; they emphasize the importance of complementary process changes to the ultimate success of HIT implementation (Miller et al, 2003). Thus, the span of an organization's planning horizon or commitment to clinical and business process redesign may also influence adoption decisions.

Evidence suggests that the implementation of health information technologies can lead to a reduction in medical errors (Hillestad et al, 2005). As such, there may be a motivation to adopt HIT as a means through which to reduce malpractice risk. Malpractice premiums may be a suitable measure for analysis partially due to the fact that there is a large degree of variation in medical malpractice premiums across states and within states in urban localities; this variation is partially due to the fact that malpractice insurance is primarily regulated by individual states (Mello, 2006).

Literature searches do not render any previous research in this area, so the present analyses are exploratory. However, an article in one industry journal provides some evidence that health care organizations are cognizant of a connection between HIT, medical errors, and malpractice costs and are implementing technologies such as electronic medical records to enhance risk-management (Performance Improvement Advisor, 2005).

Hospital Profit-Status and Adoption

RAND researchers find that non-profit hospitals lead for-profits considerably in the implementation of clinical HIT applications, whereas for-profits are ahead in the adoption of managerial-oriented IT systems (2005). Wang and Wan find that for-profits are more likely to implement IT "systemically" throughout the organization (2002).

In a 2003 paper, Parente and Van Horn explore how the operational goals of for-profits and non-profits may drive the benefits these differing types of organizations receive from the implementation of HIT systems. The authors find that IT systems in for-profits serve to reduce total patient-days, but increase the quantity of services and discharges in non-profits; they find these results to be consistent with the differing objectives and maximands of profit-orientation (Parente and Van Horn, 2003). This study finds that adoption in non-profit hospitals is more pervasive and these institutions tend to be earlier adopters of HIT.

Health Care Financing and Adoption

In a 2002 paper, Borzekowski explores the relationship between health care financing and HIT adoption. He uses 1982-1984 data to design a natural experiment of the impact of the 1983 implementation of the Medicare prospective payment system (PPS) on the adoption of HIT. The PPS imposes a fixed diagnosis-based reimbursement schedule on hospitals and introduces risk-sharing which was designed to reduce costs. He finds that hospitals increased their adoption of HIT systems in response to implementation of PPS and that hospitals with the greatest incentives to lower costs (those having higher proportions of PPS – or Medicare – patients) were more likely to adopt (Borzekowski, 2002). Considering the substantial cost and organizational change inherent in adopting an HIT system, it is surprising that Borzekowski found such a rapid two-year adjustment in the adoption of these systems.

Gaps in the Research

Although there is a small body of research documenting hospital characteristics that influence the adoption of HIT and associated relationships to payer-mix, more study is required. While the comprehensive RAND paper covers a breadth of important topics and considerations, findings are primarily descriptive with the exception of multivariate regression analyses for acute-care hospitals. Additionally, this study examines only 2004 data and does not employ transition models to further isolate potential drivers of adoption over time. The present paper will differ from the RAND study in a number of ways, including: use of three multivariate regression models including a transition model, inclusion of a broader measure for managed care payers (i.e., collapsing HMO and PPO revenues), and inclusion of malpractice cost data. The present analysis employs payer revenues as opposed to admissions to capture payer-mix in regression models. Additionally, this paper does not disaggregate hospitals by type – with the exception of academic hospitals – as the RAND paper does.

Borzekowski's 2002 paper provides a robust initial analysis of how reimbursement mechanisms in the public sector may have influenced the adoption of HIT. However, data from this study are over 20 years old. In the period since these data were collected, there have been significant changes in the efficacy and availability of HIT systems, as well as broad changes in payer-mix, including further penetration of managed care as well as a greater diversity of insurance products available on the market. Additionally, changes in the structure of the Medicaid program and increasingly lower levels of Medicaid reimbursement may be important factors that have changed the nature of payer-incentives for adoption of hospital IT systems (American Academy of Pediatrics, 2005; Berman et al, 2002).

Medicare, on the other hand, has had relatively stable reimbursement rates in the past several years as compared to payments from private insurers (MedPAC, 2006). However, Medicare reimbursements were approximately 83% of those of private insurers in 2004, suggesting that from a revenue perspective, hospitals may prefer to treat patients with traditional commercial insurance because of the reimbursement differential and because they face less cost-sharing risk.

CONCEPTUAL FRAMEWORK AND HYPOTHESES

Information technology (IT) is a capital investment that a profit-maximizing organization makes when perceived benefits outweigh costs. In the United States, revenues generated by health care organizations are largely made by third party payers. Different payers use different models to determine the reimbursement that will be granted for medical procedures. For example, the Medicare program utilizes a prospective payment system (PPS) for hospital services that reimburses claims based on diagnosis rather than reimbursing cost of services rendered. This reimbursement model may induce hospitals to avoid expensive technologies or utilize fewer services in the treatment regimen.

Other payers, such as managed care organizations, capitate or limit payments per patient. Under a capitated system, incentives are likely cost-reducing in nature. The Medicaid program has historically offered sparse reimbursements. On the other hand, the most generous payers reimburse health care organizations for costs incurred to treat the patient with little cost- or risk-sharing; this reimbursement framework is called "fee-for-service" and is the mechanism used in traditional commercial insurance.

Folland, Goodman, and Stano provide the following description of the prospective payment system which is the reimbursement mechanism for Medicare hospital costs:

> Medicare's PPS limits hospital revenues per Medicare patient. Under PPS, hospitals are reimbursed a fixed amount per admission, determined by the patient's diagnostic condition, regardless of the hospital's actual costs. The strategy behind PPS is simple. By limiting revenues, it provides hospitals with strong disincentives to extend lengths of stay and provide unnecessary or marginal care (2004).

Thus, hospitals treating Medicare patients adopt a degree of cost risk; they will share in the cost of treatment if services are performed that cost more than the fixed reimbursement level for a particular diagnosis.

Because different payers offer different sets of incentives that may play into the decision to utilize technology, the payer-mix that a health care organization faces may influence decisions to adopt HIT. A 2005 study by Hillestad et al provides evidence that IT is a cost-saving technology in the health care sector. This may suggest that organizations facing the most significant cost-saving (risk-sharing) challenges have the most to gain from implementing IT and are thus more likely to adopt. However, the implementation of HIT can be expensive from capital cost and labor resource perspectives – so, organizations facing the strongest reasons to adopt these technologies may not have the resources to adopt.

For the purposes of this research, fee-for-service payers (i.e., traditional commercial insurance) will be considered a "generous payer" that exacts little cost-sharing pressure. Medicare, Medicaid, and managed care payers will be conceived of as plans offering incentives to reduce costs. This framework informs our hypothesis:

Organizations receiving different mixes of payer reimbursements will have dissimilar probabilities of implementing HIT because of the varied financial incentives established by alternative payment models.

Dissimilar probabilities of HIT implementation may suggest that there are differing degrees of alignment between payer reimbursement incentives and organizations' decision to adopt these technologies.

Both status models and entry models are used to test this hypothesis. A malpractice insurance cost variable is included to test whether medical malpractice premiums influence the decision to adopt HIT. Because there is some evidence suggesting that HIT can reduce medical errors, and medical errors can drive malpractice rates, we posit that the association is positive.

STATUS MODELS

Prob {Clinical Technology Presence=1} = β0 + β1FFS + β2ManagedCare + β3Medicare[1] + β4Medicaid + β5OtherPayer + β6Profit + β7abovemeanlnBeds + β8Teaching + β9Rural + β10Malpractice + ε

Null hypotheses	Alternative hypotheses
$\beta_1 = 0$	$\beta_1 \neq 0$
$\beta_2 = 0$	$\beta_2 \neq 0$
$B_4 = 0$	$\beta_3 \neq 0$
$\beta_5 = 0$	$\beta_5 \neq 0$
$B_{10} = 0$	$B_{10} > 0$
(Test for joint significance) $\beta_1 = 0$ and $\beta_2 = 0$ and $\beta_4 = 0$ and $\beta_5 = 0$	βs 1, 2, 4, 5 not equal to zero

[1] Medicare is our reference category and thus will be removed from the regression. It is presented in this equation for illustrative purposes.

Entry Models

$$\text{Prob}\{\text{ClinicalAdoption2004}=1 \mid \text{ClinicalAdoption2003}=0\} = \beta 0 + \beta 1\text{FFS}_{2003} + \beta 2\text{ManagedCare}_{2003} + \beta 3\text{Medicare}_{2003}{}^{2} + \beta 4\text{Medicaid}_{2003} + \beta 5\text{OtherPayer}_{2003} + \beta 6\text{Profit}_{2003} + \beta 7\text{abovemeanlnBeds}_{2003} + \beta 8\text{Teaching} + \beta 9\text{Rural} + \beta 10\text{Malpractice} + \varepsilon$$

Null hypotheses	Alternative hypotheses
$\beta_1 = 0$	$\beta_1 \neq 0$
$\beta_2 = 0$	$\beta_2 \neq 0$
$\beta_4 = 0$	$\beta_4 \neq 0$
$\beta_5 = 0$	$\beta_5 \neq 0$
$B_{10} = 0$	$B_{10} > 0$
(Test for joint significance) $\beta_1 = 0$ and $\beta_2 = 0$ and $\beta_4 = 0$ and $\beta_5 = 0$	βs 1, 2, 4, 5 not equal to zero

Data and Research Design

Data

The primary data set for this research project is the HIMSS-Dorenfest Database, previously known as the Dorenfest IHDS+TM Database. This data set is collected and administered by the Health Information Management Systems Society (HIMSS), which is a health care industry membership organization focused on the use of information technology and its application in the health sector.

[2] Medicare is our reference category and thus will be removed from the regression. It is presented in this equation for illustrative purposes.

Data from HIMSS-Dorenfest is supplemented by data from the American Association of Medical Colleges, Council of Teaching Hospitals and Health Systems (COTH) to identify which health delivery systems have a teaching/academic affiliation.

In order to determine if medical malpractice costs may contribute to the decision for a health care organization to implement health information technology, a measure of malpractice costs is included at the state-level and for localities within states that have different costs than the rest of their state such as large urban areas.

This measure is the medical malpractice expense geographic practice cost index (GPCI) which is generated by the Centers for Medicare and Medicaid Services (CMS) and reflects premiums paid by physicians for professional liability insurance. This index is included in the Medicare reimbursement rate formula and is one of three separate indices that raise or lower Medicare fees in an area depending upon whether that area's physician practice costs are above or below a national average (GAO, 2005). The other two are for physician work and practice expenses. GPCIs are expressed as the ratio of an area's cost to the national average cost; the malpractice GPCI is based on average malpractice premiums in a payment locality.

DATA SET POPULATION

The HIMSS-Dorenfest Database captures data from integrated healthcare delivery systems (IHDSs) in the United States that own at least one short-term, acute care, non-federal hospital with at least 100 beds. An IHDS is a parent health care organization that may be a multi-hospital system or an umbrella organization for a number of health care facilities. The most recent (2004) data set release includes information for 1,453 IHDSs. The database includes data on over 32,000 individual facilities. However, primary analysis is performed at the IHDS level. For teaching status, facility data are aggregated to the system level because of the unit of reporting. The rationale for the system unit of analysis is that the business decision to invest in HIT comes from the upper organizational levels and may not reside in individual facilities themselves (RAND, 2005).

Data sources from the American Association of Medical Colleges, Council of Teaching Hospitals, and Health Systems (COTH) provide information on approximately 400 member institutions that train physician residents.

TIME PERIOD

Development of the HIMSS-Dorenfest Database was initiated in 1986 and is updated on an annual basis, with a progressively more detailed set of measures collected over time. Updates are released on an annual basis.

Analyses for this research project are limited to 2003 and 2004 data. The rationale for these years is that the collection of data pertaining to computerized physician order entry (CPOE) – a clinically-focused technology – is limited to 2003 and 2004.

Data from the American Association of Medical Colleges is based on the membership roster of the Council of Teaching Hospitals and Health Systems (COTH). Data used for this research project include the most recent update to the membership roster (please see “Limitations” for additional information).

Data from 2003 were used for the medical malpractice expense geographic practice cost index (GPCI).

Data Collection Approach

The HIMSS-Dorenfest Database is updated on an annual basis. HIMSS administers a demographic survey each year. Upon receipt of updated demographic data, a quality control protocol is used to ensure that inconsistencies are identified. This information is then provided to the contact at the health care organization for validation. Once results from the demographic survey have been validated, HIMSS then begins the more detailed information systems (IS) interview process. The IS interview process is initiated by contacting the organization’s Chief Information Officer (CIO) who then may delegate this activity to one or more individuals on their staff. Upon receipt of IS data, results are revalidated with organizations and are then uploaded to the data set.

Response Rate

Organizational information such as address and contact information, size, and profit-status are provided for all IHDSs in the HIMSS-Dorenfest survey population (IHDSs in the United States that own at least one short term, acute care, non-federal hospital with at least 100 beds). However, in years 2003 and 2004, a total of 1,016 of 1,414 (78.22%) provided data pertaining to payer-mix. Thus, the payer-mix "response rate" is 78.22%. A test for the statistical significance of missing data was performed by including indicators for missing payer data. The coefficients on indicators for missingness were not statistically significant in either the status or entry models.

LIMITATIONS

The HIMSS-Dorenfest Database is generated by a survey and interview process where IHDSs self-report. Although a quality control protocol is used to identify inconsistencies in responses, data are subject to the limitations of self-reporting, including respondent misunderstanding of survey items, respondent fatigue, or forced-choice responses which may distort survey responses. Random error may also be a contributing factor.

Furthermore, the HIMSS-Dorenfest Database likely underrepresents rural health care facilities because it is limited to IHDSs with more than 100 beds and organizations that are affiliated with a parent organization.

With respect to the American Association of Medical Colleges teaching hospitals data, dates of affiliation are not provided. Data is limited to the most recent membership roster. Thus, we assume that teaching status is static in the time period under consideration.

ANALYSIS PLAN

POPULATION

The HIMSS-Dorenfest Database captures data from IHDSs in the United States that own at least one short-term, acute-care, non-federal hospital with at least 100 beds. 2003 and 2004 data are used for this analysis and 78.22% IHDSs provide payer-mix data.

REGRESSION MODELS

Logit models are used in these analyses. The rationale for this model selection is that we are exploring the presence and adoption of technologies which are dichotomous dependent variables. Logit models are non-linear probability models and coefficient estimates render log-odds. To simplify interpretation, coefficients can be exponentiated and interpreted as odds-ratios.

Status models are included for 2003 and 2004. The dependent variable captures the estimated probability of the presence of clinical IT in those respective years.

The entry model introduces a time element. The adoption of clinical IT in 2004 is estimated based upon organizational characteristics in 2003. Our dependent variable estimates the likelihood that a system adopts these applications in 2004 based upon characteristics the previous year.

STATUS MODEL

$$\text{Prob}\{\text{Clinical Technology Presence}=1\} = 1/(1 + e^{(-1*(\beta0 + \beta1FFS + \beta2ManagedCare + \beta3Medicare + \beta4Medicaid + \beta5OtherPayer + \beta6Profit + \beta7abovemeanlnBeds + \beta8Teaching + \beta9Rural + \beta10Malpractice))})$$

ENTRY MODEL

$$\text{Prob}\{\text{ClinicalAdoption2004}=1 \mid \text{ClinicalAdoption2003}=0\} = 1/(1 + e^{(-1*(\beta0 + \beta1FFS2003 + \beta2ManagedCare2003 + \beta3Medicare2003 + \beta4Medicaid2003 + \beta5OtherPayer2003 + \beta6Profit2003 + \beta7abovemeanlnBeds2003 + \beta8Teaching + \beta9Rural + \beta10Malpractice))})$$

VARIABLES

DEPENDENT VARIABLES

Two dependent variables are used in these analyses; the presence of clinical IT, and the adoption of clinical IT. Dependent variables are dichotomous with values of zero or one.

INDEPENDENT VARIABLES

Descriptions of independent variables are provided in Exhibit 3.

Independent Variable	Purpose	Comments
Profit Status Dummy variable with value 0 or 1	To identify the profit-orientation of the health care system	Variables are included for 2003 and 2004
Fee-for-Service Continuous variable with values from 0 to 1	To identify the proportion of a system's revenue that comes from traditional commercial insurance	Variables are included for 2003 and 2004
Managed Care Continuous variable with values from 0 to 1	To identify the proportion of a system's revenue that comes from Managed Care plans	Variables are included for 2003 and 2004
Medicare Continuous variable with values from 0 to 1	To identify the proportion of a system's revenue that comes from Medicare	Variables are included for 2003 and 2004
Medicaid Continuous variable with values from 0 to 1	To identify the proportion of a system's revenue that comes from Medicaid	Variables are included for 2003 and 2004
Other Payers Continuous variable with values from 0 to 1	To identify the proportion of a system's revenue that comes from Other Payers	Variables are included for 2003 and 2004
Rural Status Dummy variable with value 0 or 1	To identify if the health care system is located in a rural area	Variables are included for 2003 and 2004 Derived from the total number of patients in the system's service area, where rural is set to 1 if the service area is less then 50,000 persons
lnBeds above the mean of lnBeds Dummy variable with value 0 or 1	To identify large health care systems that may face economies of scale in implementing HIT. The natural log of beds is summed over facilities in the system.	Variables are included for 2003 and 2004 A dummy variable for systems above the mean of the natural log of beds is used in regression analyses
Clinical HIT 2004 Dummy variable with value 0 or 1	To identify if physicians in the health care system use clinical IT applications in 2004	Clinical HIT is set to 1 if physicians use computerized physician order entry (CPOE) to enter all orders in 2004.
Clinical HIT 2003 Dummy variable with value 0 or 1	To identify if physicians in the health care system use clinical IT applications in 2003	Measurement of clinical HIT presence varies in the data set between 2003 and 2004. Clinical HIT 2003 is derived from whether the system's physicians do their own medication order entry and that this system is not stand alone
Teaching Affiliation Dummy variable with value of 0 or 1	To identify if the health care system is affiliated with a medical school	
Medical Malpractice GPCI Continuous variable which is an index of the system's malpractice costs compared to the national average	To identify the relative malpractice costs faced by the health care system	Localities were matched to the malpractice GPCI by cross-referencing IHDS address with the Medicare locality code

Exhibit 3: Descriptions of Independent Variables

RESULTS

Descriptive statistics are provided in Exhibit 4. Most health care organizations in our population, 95.8%, are not-for-profit, which is consistent with the national distribution of hospital profit status. Just over eleven and a half percent of health care systems in the data set serve patients in rural areas, and 16.3% of systems have an affiliation with a medical school. The organizations in our population range in size from 15 to 44,287 licensed patient beds; the systems at the top end of this distribution represent some of the largest health care systems in the country. The malpractice rates in our population are 7% below the national average.

In both 2003 and 2004, hospital systems in our population received more of their revenue, 40%, from Medicare reimbursement than from any other source. Revenue from other payer types was relatively steady during this period. The next largest source of revenue was from managed care payers. Traditional commercial insurance provided approximately 15% of system revenues in both years.

In 2003, 10.1% of health care organizations possessed clinical HIT applications. The proportion increased to 12.4% by 2004; this represents a 22.8% increase in the presence of clinical HIT during our study period. This result is consistent with the trend of increasing adoption of HIT over time. Thirty-two health care systems adopted clinical HIT between 2003 and 2004.

Variable	N	Mean	Standard Deviation	Minimum	Maximum
IHDS Characteristics (2003 and 2004)					
Teaching Affiliation	1414	0.163	0.369	0	1
Malpractice GPCI	1414	0.930	0.426	0.279	2.738
2004 IHDS Characteristics					
Rural Status	1401	0.116	0.321	0	1
Profit Status	1414	0.042	0.200	0	1
Number of Beds	1414	753.327	2134.90	15	44287
lnBeds	1414	5.892	1.036	2.708	10.698
2004 Payer Data: Payer Revenue Percentages					
Fee-for-Service	1106	0.150	0.123	0	0.66
Managed Care	1106	0.202	0.169	0	1
Medicare	1109	0.400	0.139	0	0.93
Medicaid	1108	0.142	0.120	0	0.94
Other Payer	1106	0.107	0.107	0	1
2004 HIT Data					
Presence of Clinical IT	1414	0.124	0.329	0	1
2003 IHDS Characteristics					
Rural Status	1393	0.118	0.323	0	1
Profit Status	1414	0.044	0.205	0	1
Number of Beds	1414	753.931	2181.74	15	43932
lnBeds	1414	5.891	1.035	2.708	10.690
2003 Payer Data: Payer Revenue Percentages					
Fee-for-Service	1015	0.149	0.119	0	0.66
Managed Care	1015	0.201	0.170	0	1
Medicare	1015	0.400	0.139	0	0.85
Medicaid	1015	0.143	0.125	0	0.94
Other Payer	1015	0.106	0.110	0	1
2003 HIT Data					
Presence of Clinical IT	1414	0.101	0.302	0	1

Source: Author's calculations from the HIMSS-Dorenfest Database, American Association of Medical College, Council of Teaching Hospitals and Health Systems (COTH), and the Centers for Medicare and Medicaid Services.

Exhibit 4: Descriptive Statistics

OVERVIEW

Our results provide some evidence that payer-mix variables have a jointly significant influence on the presence of clinical health information technology. Most notably, managed care revenue has statistically significant effects in both the 2004 status model and the entry model, and is estimated to increase the probability of the presence and adoption of information technology in clinical settings.

Findings for the significance and direction of rural status in the 2004 status model and teaching affiliation coefficients are consistent with the published literature. On average, rural status for a health care system decreases the likelihood of clinical IT, and teaching affiliation increases the likelihood of clinical IT.

System size is significant at the margin in the status models, where larger systems are more likely to have HIT. This is consistent with the published research, which finds a positive association between size and the presence of HIT.

One surprising finding was divergent results between the 2004 and 2003 status models, where there were no statistically significant findings in 2003 for payer variables, but coefficients on managed care and Medicaid were statistically significant in 2004. The coefficients for managed care and Medicaid were both positive and of similar magnitude.

2004 STATUS MODEL

Results from the 2004 status model for the presence of clinical IT provide evidence that payer-mix is jointly significant at greater than the 95% confidence level where p=0.0274 (Exhibit 6). Managed care has a highly statistically significant influence on the probability of the presence of clinical IT with a p-value of 0.01 (Exhibit 5). Medicaid has an independently significant influence on the probability of the presence of clinical IT, with a p-value of 0.0243 (Exhibit 5).

Results for rural status, which is negatively associated with the presence of clinical IT, and teaching affiliation, which is positively associated with the presence of clinical IT are statistically significant at about the 95% and 99% confidence levels respectively with p-values of 0.0547 and 0.0013. These findings are consistent with the published research. The dummy variable for large system size which is defined as systems with number of licensed beds above the mean natural log is significant at the margin where p=0.0802.

Dependent Variable: Presence of Clinical IT, 2004	
Independent Variables	**Logistic Coefficient**
Intercept	-3.3241** *(0.5008)*
Fee-for-Service	0.8925 *(1.1350)*
Managed Care	2.0966** *(0.8139)*
Medicaid	1.8015* *(0.7997)*
Other Payer	1.8402≈ *(0.9638)*
Profit Status	-1.2518≈ *(0.7322)*
above mean lnBeds	0.3335≈ *(0.1906)*
Rural Status	-0.8515≈ *(0.4432)*
Teaching Affiliation	0.6670** *(0.2073)*
Malpractice GPCI	0.0808 *(0.1880)*
Number of Observations = 1401	

**=p<.01
*=p<.05
≈=p<.10

Exhibit 5: Results for 2004 Status Model of Presence of Clinical HIT

Test for Joint Significance of Payer Variables, 2004	
	P
Fee-for-Service, Managed Care, Medicaid, Other Payers	0.0274*

Exhibit 6: Test for Joint Significance of Payer Variables, 2004

Because this is a non-linear model, estimates of changes in payer-mix are not the same along the distribution. In order to illustrate the influence of payer-mix on the probability of the presence of clinical IT in 2004, sample scenarios are provided in Exhibit 7. These three scenarios are simplified to examine the probability of clinical IT presence when the health care system receives revenue from just one payer source. Because of the complexity of payer systems in the United States, this is an oversimplification, but illustrates the influence of payer-mix on the presence of clinical IT applications.

Hypothetical Scenarios of Payer-Mix			
Scenario	**Probability of Clinical IT Presence if the System is Small**	**Probability of Clinical IT Presence if the System is Large**	**Probability of Clinical IT Presence if the System is Teaching-Affiliated (and Large)**
Scenario 1: All revenue is from managed care	24.1%	30.7%	46.4%
Scenario 2: All revenue is from Medicaid	19.1%	24.8%	39.1%
Scenario 3: All revenue is from other payers	19.7%	25.5%	40.1%

*In the above scenarios, health care systems are assumed to be not-for-profit, non-rural and face national average malpractice costs.

Exhibit 7: Hypothetical Scenarios of Payer-Mix

We can see from the above scenarios, that the influence of managed care revenue has the greatest positive effect on the probability of the presence of clinical IT. Estimates are also included for scenarios where health care systems are small and large (below and above the mean of the natural log of beds) and teaching-affiliated. Teaching affiliation has a highly statistically significant and strong influence on the likelihood that the health care systems use clinical IT applications. A scenario is not included for fee-for-service (i.e., traditional commercial insurance), as the coefficient for this payer type is not statistically significant.

2003 STATUS MODEL

Surprisingly, we find that payer-mix is not jointly significant in predicting the presence of clinical IT in 2003 (Exhibit 9). Only one coefficient, teaching affiliation, is highly statistically significant in the 2003 status model at the 99% confidence level (Exhibit 8). Large system size is significant at the margin with a p-value of 0.0786.

Dependent Variable: Presence of Clinical IT, 2003	
Independent Variables	**Logistic Coefficient**
Intercept	-2.9785** *(0.5641)*
Fee-for-Service	1.0356 *(1.2334)*
Managed Care	0.8336 *(0.9297)*
Medicaid	0.1791 *(1.0054)*
Other Payer	-0.0461 *(1.2313)*
Profit Status	0.2891 *(0.4233)*
above mean lnBeds	0.3794$^{\approx}$ *(0.2157)*
Rural Status	0.0127 *(0.3556)*
Teaching Affiliation	0.9797** *(0.2247)*
Malpractice GPCI	0.00468 *(0.2078)*
Number of Observations = 1393	

**=p<.01
*=p<.05
$^{\approx}$=p<.10

Exhibit 8: Results for 2003 Status Model of Presence of Clinical HIT

Test for Joint Significance of Payer Variables, 2003	
	P
Fee-for-Service, Managed Care, Medicaid, Other Payers	0.8250

Exhibit 9: Test for Joint Significance of Payer Variables, 2003

ENTRY MODEL

Results from the entry model do not support that payer-mix has a jointly statistically significant impact on a health care organization's decision to adopt clinical IT (p=0.1418). However, individual significance was found for managed care at the 95% confidence level (Exhibit 10).

The lack of evidence for joint statistical significance of payer-mix in the entry model is somewhat surprising. However, this result may be driven by the small number of 'changers' between 2003 and 2004; just thirty-two systems adopted HIT during this period.

We would expect that the adoption of clinical IT is not instantaneous. In other words, if there is a change in the revenue mix from different payers in one period, thus altering incentives to adopt clinical technologies, then the adoption of the technology will likely occur in the following period as the adoption process involves a series of planning and implementation activities that take time.

Again, the coefficient for teaching affiliation is statistically significant and has a positive direction, consistent with published research.

Neither the status model, nor the entry models find a statistically significant influence of fee-for-service revenues on our dependent variables for clinical IT in health care systems.

Dependent Variable: Adoption of Clinical IT 2003-2004	
Independent Variables	**Logistic Coefficient**
Intercept	-3.1001** *(0.5876)*
Fee-for-Service	0.6206 *(1.3615)*
Managed Care	2.0730* *(0.9536)*
Medicaid	0.5648 *(1.0323)*
Other Payer	1.5886 *(1.1220)*
Profit Status	-1.7345≈ *(1.0193)*
above mean lnBeds	0.2623 *(0.2151)*
Rural Status	-0.6728 *(0.4481)*
Teaching Affiliation	0.5455* *(0.2520)*
Malpractice GPCI	-0.0172 *(0.2192)*
Number of Observations = 1252	

**=p<.01
*=p<.05
≈=p<.10

Exhibit 10: Results for Entry Model of Clinical HIT Adoption

Test for Joint Significance of Payer Variables	
	P
Fee-for-Service, Managed Care, Medicaid, Other Payers	0.1418

Exhibit 11: Test for Joint Significance of Payer Variables in Entry Model

Discussion

Empirical evidence from these analyses tends to support the hypothesis that payer-mix has a statistically significant influence on a health care system's use of clinical HIT and its decision to adopt HIT. Regression results suggest that payer variables are jointly statistically significant in the 2004 status model, and that managed care has the largest potential impact on the presence/adoption of clinical HIT.

This finding is consistent with the RAND 2005 paper that "the share of (managed care) revenues has a strong positive correlation with CPOE adoption." This makes sense from the perspective that managed care systems, which are more controlled and 'closed' may be better able to internalize the benefits of HIT investment. There is clearly a disconnect in the alignment of incentives to adopt HIT, and, moreover, there is a somewhat perverse incentive system in the health care system. Taylor and colleagues state that for HIT adoption: "providers pay in both acquisition costs and revenue losses from practicing cost-effectively" (2005).

This misalignment of incentives begs the question as to whether failure to widely adopt HIT is a market failure. We may even want to consider the notion that there is a public good aspect to HIT, in that there are external benefits that are not recouped by a health care organization when they invest in HIT systems.

Market failure is a common rationale for government intervention. Rosenfeld and colleagues have described four types of HIT incentive systems to spur adoption, including: payment differential for providers, cost differentials for consumers, direct reimbursements to providers, and shared withholds from providers (Taylor et al, 2005). In addition to these options, there is always a "stay the course" path where providers and health systems continue to make individual adoption decisions based on perceptions of return on investment and benefits of these technologies. Descriptive data provided in this paper, as well as the published literature, find that the diffusion of clinical HIT is occurring in the absence of noteworthy government intervention. This paper finds that there was a 22.8% increase in the adoption of clinical HIT between 2003 and 2004.

As the largest health care payer in the country, the Federal government has an interest in reduced health care costs and increased quality of care; clinical HIT may be an effective instrument in bringing this about. Taylor and colleagues find that the projected annual savings from the implementation of HIT are nearly evenly divided between the 0-64 and the 65-plus age groups which suggests that "Medicare and other payers have strong incentives to initiate policies supporting HIT adoption" (2005).

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