Title
The adoption of health information technology by small and large physician organizations over time: the role of organizational ties and incentives

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The adoption of health information technology by small and large physician organizations over time: the role of organizational ties and incentives

By

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Abstract

Adoption of health information technology by small and large physician organizations: the influence of organizational characteristics and external factors over time

By

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Doctor of Philosophy in Health Services and Policy Analysis

University of California, Berkeley

Professor Stephen M. Shortell, Chair

Objective: The primary aims of this study were: (1) to describe variation in how physician practices and medical groups have adopted health information technology (HIT) functionalities over time; and (2) to test hypotheses about how external factors facilitated the adoption of HIT functionalities. Because of their potential policy relevance, two factors were closely examined: organizational ties; and incentives for the adoption and use of HIT.

Methods: Panel data from three national surveys of physician organizations were used to construct two cohorts of organizations: small and medium-sized physician practices with fewer than 20 physicians; and large medical groups with more than 20 physicians. For the first cohort, responses were collected largely in 2008 and 2012; for the second cohort, 2006 and 2012. Cross-sectional linear regression was used to examine factors associated with adoption by the first period, and linear regression fixed organizational effects was used to examine which organizations most frequently adopted HIT between the first and second periods.

Results: Large medical groups have generally adopted comprehensive HIT systems; small and medium-sized practices have not, but are making progress. Factor analysis showed consistent patterns of clustering in the adoption of HIT functionalities, suggesting the use of sub-indices in measuring adoption. Although the effects of organizational ties and incentives on the adoption of HIT over time were mixed, some clear trends emerged. In both periods, externally oriented HIT functionalities – those enabling information exchange – were much more likely to be adopted by small and medium-sized physician practices with formal ties to other organizations, such as health systems or independent practice associations, than independently owned practices. Additionally, incentives relevant to the adoption of HIT were frequently and strongly associated with the adoption of many HIT functionalities for organizations in both cohorts.

Conclusion: The road to comprehensive adoption and Meaningful Use of HIT may take longer than many have hoped, especially for small, independent organizations. Stronger ties across organizational boundaries may be required in order to achieve a healthcare system that is truly electronically connected.

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1. INTRODUCTION

This dissertation examined the adoption of health information technology by physician organizations over time in the US. The two primary aims of this study were: (1) to describe variation in how physician practices and medical groups have adopted health information technology (HIT) functionalities over time; and (2) to test hypotheses regarding how specific factors facilitated the adoption of HIT functionalities. Data from three national surveys of physician organizations are used to explore these topics.

1.1. Meaningful use policy and the adoption of HIT

Driven by longstanding concerns about the slow rate at which healthcare organizations were adopting HIT (e.g., Jha et al. 2009; DesRoches et al 2008; Gans et al. 2005; many other studies), legislation termed the ''Health Information Technology for Economic and Clinical Health Act'' (The HITECH Act) was incorporated into the American Recovery and Reinvestment Act of 2009 (Public Law 111–5), also known as "The Stimulus Package."

Perhaps the most notable component of the HITECH act was the "Meaningful Use" program – a set of incentives to promote the adoption and use of health information technology by hospitals and "eligible providers," a group including all specialties of physicians. Meaningful Use was defined according to specific criteria for the use of several HIT functionalities, with criteria set out in three stages: (1) Data capture and sharing; (2) Advanced clinical processes; and (3) Improved outcomes (Office of the National Coordinator, Meaningful Use Definition and Objectives 2013).

Additionally, the Meaningful Use incentives included two components: a positive incentive and a negative incentive. The positive incentive included financial incentives of up to $44,000 for most physicians, paid over the course of three years to physicians meeting the Stage 1 criteria by 2013. Physicians with a minimum 30% Medicaid patient volume were eligible for incentives worth up to $63,750. The negative incentive included reductions to provider Medicare reimbursements, starting at one percent of reimbursements in 2015 and increasing over time. The incentive program is further complicated because the year in which providers are held to a given stage depends on the year they first entered the Meaningful Use program; Stage 2 phases in first in 2014 but as late as 2020, while Stage 3 phases in first in 2016 and as late as 2021.

Given this, and given the large cost of the Meaningful Use incentive payments – the Congressional Budget Office estimated that spending for the bonuses and payment reductions from the penalties would increase net Medicare spending by $17.7 billion (Congressional Budget Office 2009) – policy makers and the public may want to know which physician practices have and have not adopted HIT since the government began implementing Meaningful Use policy. In fact, the US Department of Health and Human Services (US DHHS) has closely tracked progress related to the Meaningful Use program, reporting that over 50 percent of eligible providers had met the Stage 1 criteria by April 2013 (US Department of Health and Human Services 2013).

Relevance of this study

However, less information may be available about which types of organizations have adopted HIT most since Meaningful Use policy was initially implemented (e.g., Decker et al.

2012). For example, this question may be relevant if Meaningful Use policy has motivated some organizations to adopt HIT more so than others, or if some organizations simply did not have the capabilities necessary to respond. As such, this approach may help to identify the strengths and limitations of Meaningful Use policy. Thus, through the analyses described below, this study looked to inform future policy by examining which physician organizations tended to adopt relatively more HIT once meaningful use policy was implemented, which had already adopted and, just as importantly, which organizations were still holding out.

1.2. Aims of this study and contribution to the literature

This dissertation built on prior literature examining the adoption of health information technology by physician organizations, focusing on the following three areas:

First, while nearly all prior studies have used cross-sectional or pooled cross-sectional study designs in examining correlates of the adoption of HIT, this study used panel data. The use of panel data from two cohorts of physician organizations over time enabled this study to closely examine trends in the adoption of HIT functionalities over time. In particular, the study examined whether some organizations were more likely to respond to the implementation of the Meaningful Use incentives and other environmental changes related to the adoption of HIT.

Second, prior studies have tended to treat all aspects of HIT as the same, without breaking out whether different functionalities have actually been driven by different factors. With a few exceptions, nearly all prior studies have used binary measures of HIT, often reflecting whether or not physicians reported having adopted an electronic health record (EHR). However, this may miss many functionalities that are adopted as add-ons or that are available outside of electronic health records. Just because a physician organization had adopted an electronic health record does not mean they will have adopted electronic access to laboratory results, and vice versa. Thus, through exploratory factor analysis, this dissertation examined how physician organizations actually tended to adopt HIT functionalities; this analysis thus demonstrated which functionalities should be treated as conceptually similar and which were adopted through distinct processes.

Third, through multivariate regression analysis, this dissertation identified contextual factors associated with the adoption of HIT in two time periods. Two sets of analyses were conducted: (1) factors associated with relatively early adoption, prior to Meaningful Use policy; and (2) factors associated with later adoption, in the midst of the implementation of Meaningful Use policy. The analyses of earlier and later adoption allowed this dissertation to explicitly examine whether the same factors were associated with adoption in both time periods. In particular, both physician accounts of decision-making processes and organizational theory suggest that ties to other organizations may be particularly important for the decision to adoption HIT, but the literature to date has not deeply explored this factor. Specifically, it is hypothesized that organizations owned by hospitals or health systems or those affiliated with network-type organizations such as independent practice associations may be more likely to all HIT, but especially HIT functionalities enabling electronic information exchange across organizational boundaries.

1.3. Overview of primary data sources

Data from three national surveys of physician organizations were used to construct two cohorts of physician organizations. The three surveys were: National Study of Physician Organizations II (NSPO2, fielded March 2006 - March 2007); the National Study of Small and Medium-Sized Physician Practices (NSSMPP, fielded July 2007 - March 2009); and the National Study of Physician Organizations III (NSPO3, fielded January 2012 – ongoing, with data extracted in March 2013). The two cohorts included (1) 720 small and medium-sized physician practices responding to both NSSMPP and NSPO3, and (2) 101 medical groups responding to both NSPO2 and NSPO3.

Notably, the second survey period for both cohorts, including data from January 2012 – March 2013, was fielded well after Meaningful Use Policy was signed into law (in 2009) and over a year after the first Meaningful Use incentive payments were given to physicians. Thus, some of the initial effects of Meaningful Use policy were captured in the data from the second period.

1.4. Dissertation Outline

This dissertation is organized in six main chapters. The first chapter has introduced the dissertation. The second chapter discusses the current literature on the adoption of HIT and develops the conceptual approach and hypotheses. Chapter three discusses the data and analytical methods applied. The fourth chapter discusses results in three sub-sections: one for the cohort of small and medium-sized physician practices; one for the cohort of large medical groups; and a final section comparing the results for the two. Chapter five considers implications for policy and practice, and chapter six concludes the dissertation.

Several appendices are also attached. Appendix A presents analyses of non-response bias for the National Study of Small and Medium-Sized Physician Practices and the National Study of Physician Organizations III. Appendix B compares rates of EHR adoption found in this study against those from other national studies fielded around the same time. Appendix C shows the full results behind the factor analysis of health information technology functionalities discussed in the Methods chapter. Finally, Appendix D presents the full results from all multivariate regressions discussed herein.

2. LITERATURE REVIEW AND CONCEPTUAL APPROACH

2.1. Overview of literature on the adoption of HIT

Early evidence suggests that use of health information technology (HIT) by medical providers may help improve disease management and care coordination, especially for persons with one or more chronic illness (Cebul et al. 2011; Buntin et al. 2011; Holroyd-Leduc et al. 2011; Herrin et al. 2012; Bates et al. 2010). In the context of physician organizations, HIT refers to electronic medical records and other uses of information technology aiming to improve patient care, outcomes and efficiency in clinical settings, including electronic documentation, information exchange, and registries of patients with chronic diseases (Chaudhry et al. 2006; DesRoches et al. 2008; Robinson et al. 2009). Many believe that widespread adoption of HIT could dramatically improve the quality of medical care in the long run (Buntin et al. 2011; Blumenthal and Tavenner 2010), especially for more complex patients with one or more chronic diseases (Reed et al. 2012) and once stronger interoperability across organizational boundaries is achieved (O'Malley et al. 2010).

However, to date, many physician organizations have failed to adopt even the most basic health information technology (Hsiao et al. 2011; Hsiao et al. 2012; Hogan and Kissam 2010; DesRoches et al. 2008; Robinson et al. 2009; Gans et al. 2005). Since the time of the invention of the first HIT systems in the 1960s (Bohmer, Edmondson and Feldman 2003), health information technology diffused very slowly across physician organizations, at least until the mid-2000s (Hsiao et al. 2011). Even to date, progress remains limited; the US Department of Health and Human Services (US DHHS) reported that over half of physicians had met the Stage 1 Meaningful Use criteria by April 2013 (US DHHS 2013). This represents great progress, but also means that nearly half of all physicians were still using paper-based medical record systems, suggesting that there is still much progress to be made in digitizing the US health system.

Addressing this puzzle, several studies of physicians and physician organizations have identified factors associated with the early adoption of HIT, including availability of resources (DesRoches et al. 2008; Gans et al. 2005; Robinson et al. 2009), incentives for use of HIT and better care outcomes (Robinson et al. 2009), and training and technical support for providers (DesRoches et al. 2008; Gans et al. 2005; Miller and Sim 2004; Nanji et al. 2009).

Furthermore, evidence to date suggests that adopting HIT has cost physician organizations much more than it has financially benefited them in the short run (CBO 2008; Shekelle et al 2006; Kellermann and Jones 2013). As the Congressional Budget Office (2008) discussed, the total costs of implementing an HIT system include four main components: (1) initial fixed costs of hardware, software and technical assistance required for system installation; (2) licensing fees; (3) system maintenance costs; and (4) opportunity costs of time spent during the implementation process leading to a loss of productivity (CBO 2008: p17). In particular, the implementation process has frequently had an especially negative impact on provider work-flows, meaning that providers must work longer each day while seeing fewer patients, a great source of frustration (Niazkhani et al 2009; Spellman Kennebeck et al 2011). In addition to these substantial costs associated with adopting health information technology, physicians have also expressed concerns about future obsolescence of purchased technology and about a lack of interoperability with hospitals (Ash et al. 2011; DesRoches et al. 2008; Gans et al. 2005; Miller and Sim 2004).

As this literature documented, precisely because of these concerns, most physicians and their organizations have decided to hold off on adopting health information technology, at least until very recently. Without a compelling business case (e.g., increasing profitability) or pressure from a source external to the organization (e.g., incentives, coercion from a parent organization, a governmental mandate, etc.), most organizations were content to wait for the quality and usability of the technology (and the business case) to improve.

Crucially, these studies also provided the basis for the inclusion of incentives and reimbursement reductions tied to "meaningful use" of health information technology into the American Recovery and Reinvestment Act of 2009 (Pub. L. 111–5), an attempt by Congress and President Obama's administration to stimulate adoption.

Recent evidence on the adoption of HIT by physician in outpatient settings

Although limited research has established the magnitude of the effect of Meaningful Use policy to date, rates of providers reporting they have adopted any electronic medical record system has risen rapidly in recent years, from 48 percent of office-based physicians reporting that they had any EMR/EHR system in 2009, when Meaningful Use policy was passed, to an estimated 72 percent in 2012 (Hsiao et al. 2011). Farzad Mostashari, National Coordinator for Health Information Technology within Department of Health and Human Services (US DHHS), recently reported that HIT adoption and use was "on the march" and that "every indicator we have, it's all pointing in the right direction" (Brailer et al. 2012).

However, the proportion of physicians having adopted an EHR system with the capability to fulfill the Meaningful Use Stage One criteria is much lower than the proportion having adopted any EHR system. By 2011, only an estimated 38 percent of primary care physicians and 19 percent of specialist physicians had adopted such systems (Patel et al. 2013), although a more recent report from DHHS suggests that the rate of adoption for Stage One-compliant systems had increased to 50 percent of all office-based physicians by 2013 (US DHHS 2013).

Additionally, it is unknown whether Meaningful Use policy has lifted the level of information technology equally 'for all boats' or will lead to a system where certain healthcare organizations are systematically left behind. In fact, in a study drawing on pooled cross-sectional data from the National Ambulatory Medical Care Survey, Decker et al (2012) showed that younger physicians, those in larger organizations and those in organizations owned by another entity all adopted "any EHR" more than other physicians between 2002 and 2011. (However, Decker et al found that these three factors made much less of a difference for the adoption of "Basic EHR" systems between 2007 and 2011, suggesting that the factors have not more recently driven the adoption of Meaningful Use-compliant systems.) Although early evidence remains mixed, this question of whether Meaningful Use Policy will affect all organizations equally is an especially important one, because policy makers may want to consider additional efforts if Meaningful Use Policy systematically leaves behind some physicians.

Thus, even given the substantial body of research on the adoption of health information technology by physician organizations, much remains to be learned. This dissertation attempts to build on prior literature, by developing stronger measures of the adoption of health information technology, and by exploring the role of ties to other healthcare organizations in

the decision by physician organizations to adopt health information technology. The remainder of this chapter will discuss the following, building to the development of hypotheses: the measurement of the adoption of health information technology, the necessarily temporal nature of adoption studies, and factors associated with adoption.

2.2. Measuring the adoption of HIT

Prior empirical studies on the adoption of HIT by physicians have provided important information to policy makers (Hsiao et al. 2012; Hogan and Kissum 2010; DesRoches et al. 2008; Robinson et al. 2009; Gans et al. 2005). However, these and other prior studies have generally neglected to explore both individual functionalities and measures of HIT that reflect how it is adopted by physicians in reality. Thus, one primary aim of this dissertation is to construct indices of health information technology functionalities incorporating organizational theory, the experience of physicians, and metrics of how individual functionalities cluster together in adoption. In "Scale construction and psychometrics for social and personality psychology" Furr (2011) discusses two important components of a scale: (1) internal reliability and (2) theoretical and practical validity. While internal reliability is determined through metrics of inter-item correlation, such as the Cronbach's alpha, theoretical and practical validity must be argued. Thus, below, two general approaches to developing indices of HIT will be taken: the first incorporating organizational theory and the qualitative experience of physicians; and the second incorporating metrics of how individual functionalities cluster together in adoption.

A theoretical approach to measuring the adoption of HIT

First, based on organizational theory and prior qualitative research, HIT functionalities can be divided into two distinct categories – internally oriented functionalities and externally oriented functionalities. Relating to tasks occurring within the physician practice, internally oriented HIT functionalities can assist with the documentation and tracking of patient information, can support tasks related to population management, and can give providers and practices clear and timely information for improving quality of care. In contrast, externally oriented functionalities help to link practices to other entities, such as other physician practices, hospitals, regional health information exchanges, insurers, and patients. Thus, externally oriented functionalities serve to assist with care coordination through the secure transmission of patient healthcare information outside of the physician practice.

Centrally, internally and externally oriented functionalities may face different organizational facilitators and constraints to being adopted. To adopt internally oriented functionalities, practice leaders must decide to purchase and implement their chosen software, hardware, and technical assistance. While no small task, the adoption of internally oriented functionalities can be done through a primarily internal process.

In contrast to the process of adopting internally oriented HIT, adopting externally oriented HIT entails explicit interdependence with other providers and organizations in the healthcare system, in addition to the technical infrastructure and know-how required for the adoption of internally oriented HIT. Having to rely on the willingness and ability of other providers and organizations (e.g., hospitals, pharmacies, other physician organizations, etc.) to participate in information exchange may create an additional barrier to the adoption of externally oriented HIT. As Gold et al. (2012) discuss, "no one party has the authority to create

more robust forms of electronic [health information] exchange… Successful exchange also ultimately requires that individual providers be willing—and able—to share" (p518). For this reason, it was hypothesized that internally oriented and externally oriented functionalities may be adopted through distinct processes, and therefore should be examined as separate measures.

A data driven approach to measuring the adoption of HIT

Examining indices and sub-indices of HIT adoption for internal reliability represents a second method of identifying coherent subsets of health information technology. Although the constructs of internally and externally oriented HIT, discussed above, have theoretical validity at a broad level, internal reliability must be determined separately, using quantitative methods (Furr 2011). Additionally, even within the constructs of internally and externally oriented HIT, some items could potentially be divided into even smaller sub-indices. For example, the decision to adopt laboratory reports may not be related to the decision to adopt email, even though both functionalities are broadly used for communication.

Thus, under this approach, sub-indices will be constructed by combining HIT functionalities that physician organizations tend to adopt jointly based on exploratory data analysis. This acknowledges that HIT functionalities will rarely be adopted "one at a time," while organizations will also rarely adopt every single existing HIT functionality all at once. This dissertation will also examine whether the clustering of HIT functionalities changed over time or differed by organization size. It is possible, for example, that patterns of HIT adoption earlier was different from patterns later, because of improvements in the technology, or the customization of the technology by early adopters (Westphal et al. 1997), and other reasons.

2.3. Drivers of the adoption of HIT over time

While the landscape for adoption and use of HIT in medicine has changed substantially over the past half-decade (Hsaio et al. 2011), the vast majority of studies examining the adoption of HIT nationally have used cross-sectional designs, looking only at snapshots of data from a given period, making it difficult to say much about drivers of trends over time.

In contrast, drawing on longitudinal data from two cohorts of physician organizations, this dissertation incorporated temporal dynamics into the study in two ways. First, early adoption (in 2006 or 2008, depending on the cohort) and later adoption (in 2012) were examined separately. This allows for the comparison of the magnitudes of factors across the two periods. Second, in studying later adoption, the use of panel data enabled the study to examine the effects of factors at baseline (in 2006 or 2008) on the later adoption of HIT and the effects of how those factors changed over time.

This temporal perspective is especially important in examining the adoption of HIT because a large body of literature in the area of implementation science and organizational theory suggests that early adopters are typically driven by fundamentally different motives than later adopters. In his study of the adoption of innovations by farmers, Rogers (1962) suggested that persons adopting innovations before others (early adopters) would have a higher tolerance for risk than their colleagues, be younger and have greater financial flexibility. Moreover, while early adoption is enabled by an ability and willingness to take risks, adoption by the majority of actors in an established field occurs as word is spread through networks (Westphal et al 1997)

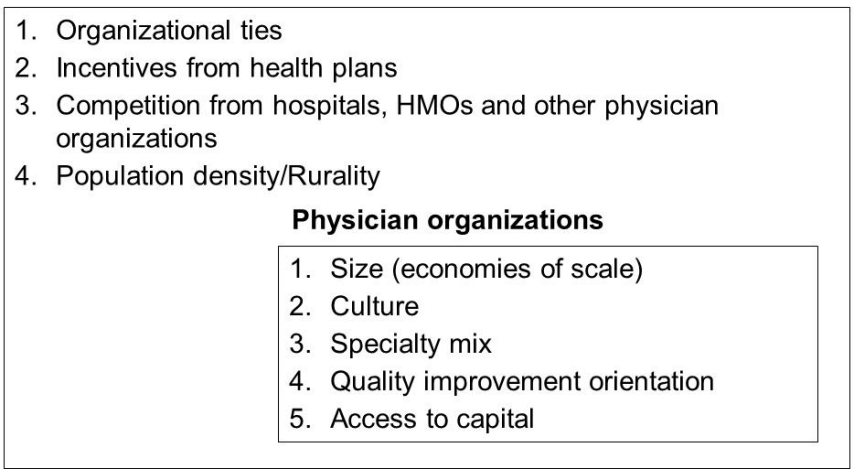
and innovations are deemed necessary for an organization to maintain its "legitimacy" (Strang and Meyer 1993). Following from this logic, it is possible that factors such as access to resources and concerns about diminished productivity in the short run may matter less for organizations considering adoption later in the diffusion process, in comparison to early adopters.

2.4. External factors and the adoption of HIT

Although the literature to date on the adoption of health information technology by physician organizations emphasizes the role of organizational characteristics (e.g., practice size), physician accounts of the process of deciding whether to adopt HIT suggest that physician organizations may also experience an extensive set of external pressures and cues (Skolnik et al. 2011; Adler-Milstein, Bates and Jha 2009; Frisse 2005; Mostashari, Tripathi, and Kendall 2009).

These accounts are reinforced by organizational theory (DiMaggio & Powell 1983; Meyer & Rowan 1977; Hannan and Freeman 1984; Pfeffer and Salancik 1978) and applications of organizational theory in other settings which stress the importance of external factors on organizational behavior. Organizations are influenced by the expectations, norms and values of their clients, collaborators and competitors (Meyer & Rowan 1977; Powell and DiMaggio 1983; Tolbert and Zucker 1983; Haveman 1993), by interdependence with other organizations (Pfeffer and Salancik 1978), by the flow of information from their network ties (Grannovetter 1985; Davis 1991; Uzzi 1996; Westphal et al. 1997), and by incentives faced for particular behaviors, in light of the competitive landscape (Friedman 2002; Abrahamson and Rosenkopf 1993) (**Figure 1**).

Figure 1: Factors associated with adoption of HIT by physician organizations



Although this theory suggests that physician organizations' environments may affect when and how they adopt any innovation, limited research has been published explicitly examining the effect of external factors on the adoption of HIT by physician organizations (one exception being Menachemi et al. 2012, which reported mixed findings on the effects of market factors). Evidence of geographic variation in the adoption of HIT from the National Ambulatory

Medical Care Survey lends further support for looking into contextual factors (Hsiao et al. 2011).

Difficulty in measuring many of these concepts represents perhaps one major reason that the quantitative literature on the adoption of HIT has tended to omit environmental factors from analyses. For example, studying the effect of local norms might only be possible in a comparative case study. Likewise, identifying the effect of peer pressure would require detailed network data on the connections between the physician organizations within a community. Neither of which was in the scope of this study. The inability of studies relying on national survey data to adequately measure these and other environmental is an important limitation of this literature, in general. Especially to the extent that environmental factors correlate with other factors known to be correlated with the adoption of health information technology, e.g., if larger organizations also have larger networks, then it is possible that some of the current findings in the literature may be moderately positively biased.

Given this, the present study explores two sets of external factors that can be measured with reasonable accuracy, both of which may have a strong bearing on the adoption of HIT and which have been under-emphasized in the literature to date: (1) ties with other healthcare organizations; and (2) incentives for the adoption and use of HIT.

Ties with other healthcare providers and organizations

Broadly speaking, the set of connections (or "ties") in the healthcare sector between providers and organizations is highly intertwined and complex. A few examples of such ties are: ownership arrangements that tie physicians to hospitals, referral relationships tie physicians to other physicians and organizations, and network-like organizations (e.g., independent practice associations) bring together competing providers in bargaining with health plans (Robinson and Casalino 1996). Physician organizations may gain many benefits from having these formal relationships with other healthcare providers and organizations. These ties may benefit organizations in several ways: they may help the organization secure financial assistance, find new patients, gain negotiation power, access better information, and provide other benefits. In particular, ownership arrangements and affiliations with network-type organizations are discussed.

<u>Ownership arrangements</u>. The majority of physicians in the US practice in organizations that are privately owned. Decker et al (2012) estimated from the National Ambulatory Medical Care Survey that 65 percent of office-based physicians in the US practiced in a setting owned by a physician or physician group. In such settings, physicians have great autonomy, deciding which hospitals to associate with and generally operating as their own personal businesses. However, other physicians may choose to work in a practice owned by a hospital, health system, or HMO (health maintenance organization). While these ownership agreements alone may not affect the nature of care physicians provide to their patients, they likely do change how physician organizations are managed.

In particular, physician organizations owned by a hospital, health systems or HMO may be much less likely than independently owned organizations to have affiliations with multiple hospitals. They may also be less likely to be able to independently decide to adopt new technologies, such as electronic health records. Parent organizations may subsidize their physicians to adopt certain HIT systems and, in fact, they may require it (e.g., Parish 2012). To

take an extreme example, physicians working in Kaiser Permanente-affiliated physician organizations must use the Kaiser EHR system.

This discussion also dovetails neatly with the theory of resource dependence (Pfeffer and Salancik 1978), which suggests that organizations will be more likely to co-operate in achieving a mutual goal when they are otherwise interdependent. While independently owned physician organizations may strategically decide not to adopt an HIT system compatible with only some of their partner organizations, physician organizations owned by another entity may have little choice in the adoption decision. Thus:

> **H1:** Physician organizations owned by hospitals, health systems, or HMOs will be more likely than independently owned organizations to adopt HIT early on than other organizations.

Additionally, while ownership may represent another means of achieving the scale necessary to rationalize adopting an HIT system, ownership also explicitly entails interdependence between the physician organization and the parent organizations. This characteristic of the relationship – interdependence – may especially facilitate the adoption of externally oriented HIT functionalities that improve communication between the organizations. As Gold (2012) argues, health information exchange necessarily entails two parties, and organizations that are formally tied to each other through an ownership agreement may be especially more willing in comparison to others to adopt externally oriented HIT. That many healthcare organizations consider health information to be a valuable resource, which should be guarded carefully in competitive environments, makes this interdependence even more salient (Adler-Milstein, Bates, and Jha 2011; Adler-Milstein and Jha 2012; Grossman, Kushner, and November 2008). Accordingly:

> **H1a:** Physician organizations owned by hospitals, health systems, or HMOs will be more likely than independently owned organizations to adopt externally oriented HIT early on, especially to the extent that functionalities improve communication with those external entities.

A corollary of these hypotheses is that the importance of ownership as a facilitator of adoption may decrease as pressures to adopt HIT increase for all other factors. Organizational theory suggests that as an innovation diffuses mimetic/imitation pressures for non-adopters to adopt will increase (DiMaggio and Powell 1983; Strang and Meyer 1993) and the information-rich networks in which many early adopters are often embedded may become less salient as knowledge about the innovation diffuses (Westphal et al 1997). Additionally, in the case of health information technology, three additional factor to which all organizations were exposed may also have reduced the relevance of factors such as organizational ties: (1) the federal government implemented Meaningful Use policy; and (2) the usability of health information technology has continued to improve over time.

> **H1b**: As adoption of a given measure of HIT increases over time, due to increased imitation pressures, the association between ownership and the adoption of HIT will diminish.

Network-type arrangements. Taking the perspective developed by Grannovetter (1985), Uzzi (1996) and other scholars of network theory, entities are embedded in social networks through which they gain information and other valuable resources. In his classic piece examining the effect of social networks on candidates' job searches, Grannovetter (1985) found

that "weak ties" – that is, more distant and diverse connections – were more likely to result in information leading to a job than "stronger ties." Like job-seekers (Grannovetter 1985) and garment makers in Manhattan (Uzzi 1996), physician organizations are also embedded in complex social networks through formal and informal ties to other entities.

For physician organizations, these networks ties are formalized through organizations, such as independent practice associations (IPAs) or physician-hospital organization (PHOs), which bring together physician organizations and hospitals under agreements looser than ownership arrangements (Robinson and Casalino 1996). Physician organizations may enter into these agreements because they are financially beneficial with respect to bargaining with health plans and securing new patients (Robinson and Casalino 1996; Robinson 1999), but these agreements also legally require that the physician organizations be "clinically integrated" into the IPA or PHO (FTC and DOJ 2011). Because of this, IPAs and PHOs may be more likely to provide HIT to their affiliate physician organizations, to the extent it contributes to clinical integration. For example, registries may contribute to clinical integration, by improving the ability of organizations to do population management for groups of patients.

Additionally, as Lake, Collins Higgins and Ginsburg (2011) found in a recent case study of five IPAs, the IPAs arguably went beyond what was legally necessary, and "provided coordinated assistance with HIT activities to otherwise independent and relatively small physician practices" (Lake, Collins Higgins and Ginsburg 2011: 1). Not only did these IPAs act to pool the resources of many smaller organizations, but they also served as a source of information by providing a platform for "HIT-knowledgeable physician leaders to help less-technologically savvy clinicians" (Lake, Collins Higgins and Ginsburg 2011: 1). By this logic, it is likely that physician organizations affiliated with an IPA or PHO will be more likely than others to have adopted HIT.

> **H2:** Physician organizations affiliated with an independent practice association or a physician-hospital organization will be more likely than others to adopt HIT early on.

As with ownership, the effects of affiliations with independent practice associations and physician hospital organizations may diminish over time, as HIT becomes more wide-spread.

> **H2a**: As adoption of a given measure of HIT increases over time, due to increased imitation pressures, the association between affiliation with an IPA/PHO and the adoption of HIT will diminish.

Direct and indirect incentives

Economic theory around incentives suggests that when actors receive a subsidy for a given behavior, they will be more likely to do that behavior. Of course, as Friedman (2002) discusses at length, the size of the effect of a given incentive will depend on actors' initial preferences and budget constraints. Accordingly, incentives will be most effective when actors would be willing to do a certain behavior but do not perceive a sufficient incentive to do so currently. Thus, incentives for the adoption or use of HIT may not motivate all organizations equally to adopt HIT, but may increase rates of adoption for organizations "on the margin" if incentives are sufficiently large. Additionally, as Robinson et al (2009) and Williams (2010) discuss, incentives to adopt health information technology can be divided into two primary categories: direct financial incentives for the adoption of HIT and indirect financial incentives, which may lead organizations to derive greater value from HIT through means other than direct

payments. These two types of incentives may effect adoption differently and so are discussed separately below.

Direct incentives. In the case of HIT, direct incentives include cases where organizations have the opportunity to receive bonus income for the adoption or use of HIT; before Meaningful Use policy was implemented, these incentives were most frequently provided by health plans. Prior studies suggest that incentives from pay for performance (P4P) programs have had a relatively moderate but positive and statistically significant effect on the adoption of HIT by physician organizations (Robinson et al. 2009; DesRoches et al. 2008; Simon et al. 2005; Williams 2010). The earliest commercial health plans began developing pay for performance programs in the late 1980s (Williams 2010). By 2004, according to Rosenthal and colleagues (2006), around 45 percent of HMOs in the US (113 out of 252 in their sample) offered some kind of pay for performance program for physicians.

Although prior qualitative research indicates that leaders of physician organizations have not considered direct pay for performance incentives to adopt HIT to be "an important stimulus for new investments" in HIT, leaders did report that "these incentives did influence the types of [HIT] implemented" (Williams 2010: 2). Still, while many pay for performance program incentives may not be sufficiently large to cover the full cost of adopting an HIT system, by highlighting HIT as an important in and of itself or as a means to another end, such as higher quality care, these programs may have pushing organizations to consider adopting HIT when they otherwise would not have. In fact, in a study of large physician organizations, Robinson et al (2009) found that being evaluated by external entities such as health insurance plans for use of HIT was associated with a moderately-sized one point increase in the adoption of HIT functionalities on an index scale of 0-19 HIT functionalities. Thus, exposure to direct pay for performance incentives – not including the effects of the Meaningful Use incentives – to adopt or use HIT may be moderately associated with the adoption of HIT functionalities.

> **H3:** Organizations reporting the opportunity to receive bonus income from the adoption or use of HIT early on may be more likely to have adopted HIT early on than other organizations.

As Meaningful Use policy is implemented, the effects of other pay-for performance programs may diminish, if they are washed out by the relatively large and highly visible incentives and penalties associated with Meaningful Use.

> **H3a**: As the Meaningful Use program is implemented, the association between direct incentives and the adoption of HIT will diminish.

Indirect incentives. Indirect incentives can include both financial incentives and non-financial motivators for non-HIT related activities, so long as HIT could plausibly assist towards achieving those aims. For example, in some cases, the use of information technology has enabled providers to improve their scores on process outcomes, leading to improvements in healthcare outcomes to their patients (e.g., Reed et al. 2012). Thus, organizations with the opportunity to receive bonus income for high performance on patient satisfaction or measures of clinical quality might be marginally more likely than others to have adopted HIT, if they thought HIT could improve their performance on those measures (Robinson et al. 2009; Williams 2010). Likewise, organizations enrolled in public reporting programs, where data on the quality of their care are reported widely, might also be more likely to have adopted an HIT

system, to better and more easily track provider performance or to use prompts/reminders from electronic medical records in order to bring up their scores on reported metrics.

> **H4:** Organizations exposed to incentives for outcomes other than the adoption of HIT but for which HIT may indirectly make easier to achieve may be more likely to have adopted HIT early on.

As with direct incentives, as the Meaningful Use policy is implemented, the effects of other indirect incentives for the adoption of HIT may diminish, if they are washed out by the relatively large and highly visible incentives and penalties associated with Meaningful Use.

> **H4a**: As the Meaningful Use program is implemented, the association between indirect incentives and the adoption of HIT will diminish.

3. METHODS

3.1. Study design

This study has two primary aims: (1) to examine the level at which physician organizations adopted health information technology over time; and (2) to identify the effects of organizational ties (as measured by ownership and affiliation with network-type organizations) and incentives on the adoption of health information technology by physician organizations. A key component within both aims was to explore trends over time, a significant gap in the literature to date.

In achieving these aims, this study used longitudinal data from two cohorts of physician organizations. The first cohort included 101 large physician organizations (having 20 or more physicians in the first period), with data collected primarily in 2006 and in 2012; the second cohort included 720 small and medium-sized physician organizations (having 19 or fewer physicians in the first period), with data collected primarily in 2008 and 2012. The use of longitudinal panel data allowed for the application of analytical approaches emphasizing differences between early adopters, later adopters and non-adopters in analyses related to both aims. Differences between small/medium and large organizations will also be examined.

3.2. Data sources

To test the hypotheses proposed in the second section, this study used panel data from two time periods for two cohorts of physician organizations. The primary data used for this study consistent of responses to surveys from leaders physician organizations collected in three waves of the National Study of Physician Organizations (NSPO) (**Table 1**). The first wave of surveys collected responses from large physician organizations with 20 or more physicians (March 2006 - March 2007); the second wave collected responses from small and medium-sized physician organizations with 19 or fewer organizations (July 2007 - March 2009); and the third wave collected responses from all sizes of physician organizations (January 2012 – ongoing, with data extracted in March 2013). When possible, respondents in the first two waves were also included in the third wave, creating two panels (or cohorts) of physician organizations over time. One panel consists of large organizations roughly between 2006 and 2012; and a second panel consists of small and medium-sized organizations roughly between 2008 and 2012.

Survey data from the National Study of Physician Organizations is uniquely suited to answering questions about use of health information technology, because physician organizations typically make the decision to adopt HIT not independently but at the organizational level. Organizational leaders may also know best about their organization's HIT functionalities and other organizational characteristics typically associated with the adoption of HIT, such as size, specialty mix, and participation in quality improvement programs.

First period, large organizations: National Study of Physician Organizations II (NSPO2)

The data for this analysis derive from the second round of the National Study of Physician Organizations (NSPO), the major focus of which has been the use of chronic care management processes for asthma, congestive heart failure, depression, and diabetes, and the organizational factors associated with that use. The second-round survey instrument (NSPO2) used to collect the data was based on that used for the first round. Casalino et al (2003) discussed the development and testing process of the initial survey. Both first- and second

round survey instruments are available at the NSPO web site (http://nspo.berkeley.edu/). The first round of the NSPO survey was not used in this study, because it included few questions related to health information technology.

Table 1: Comparison of NSPO datasets

Dataset	When in field	Majority Year	N Total	N physician practices [a]	N medical groups [b]	Response rate
NSPO2	3/2006 – 3/2007	2006	538	--	338	60.3
NSSMPP	7/2007 – 3/2009	2008	1,744	1,744	--	63.2
NSPO3*	1/2012 – Ongoing	2012	1,095**	159**	936**	43.6**

Notes: [a]Physician organizations with fewer than 20 physicians. [b]Physician organizations with 20 or more physicians. *NSPO3 Survey is still in field, so data are not yet final, but are not expected to change dramatically. **For completed responses, extracted March 2013.
Abbreviations: NSPO2, National Study of Physician Organizations II; NSSMPP, National Study of Small and Medium-Sized Physician Practices.

A list was developed of all medical groups and IPAs in the United States with 20 or more physicians, based on information from the Medical Group Management Association, Cattaneo and Stroud, Dorland Healthcare Information, and the Integrated Healthcare Association (Robinson et al. 2009b; Shortell et al. 2009). The sampling frame was focused on medical groups with 20 or more physicians and on independent practice associations (IPAs). Physician entities associated with academic medical centers (e.g., faculty practice plans) and physician groups that do not treat at least one of 4 major chronic illnesses (asthma, diabetes, congestive heart failure, depression) were excluded.

Of the 1520 physician organizations identified, 1162 were able to be contacted to ascertain whether they met study criteria. Of these, 480 were ineligible to participate because they did not meet study criteria, resulting in an eligibility estimate of 58.7% (682/1162). This eligibility estimate was applied to the 358 organizations that were not able to be contacted, after multiple attempts, to verify that they met the study's eligibility criteria. This provided an estimated 210 eligible organizations (0.587 x 358) from among those were not contactable (AAORP 2009; Campbell et al 2007). The total number of eligible organizations hence was calculated to be 892 (210 + 682).

The medical director or chief administrator of every organization fitting the study criteria was contacted and asked to participate in a 35-minute structured survey. Respondents were reimbursed $150 for the value of their time. A total of 338 medical groups and 200 IPAs participated in the study, for an adjusted response rate of 60.3%. The adjusted response rate for medical groups alone was 58.7%. Interviews were conducted by telephone between March 2006 and March 2007. There were no statistically significant differences in response rates across geographic regions or between medical groups and IPAs.

For this study, the analytical sample was restricted to medical groups only, with independent physician associations (IPAs) omitted, because they were not included in the

second round of data collection and because the focus of the study was on medical groups and private practices. In particular, IPAs differ from other physician organizations in that they are loose network-type organizations and are not directly involved in the provision of medical care.

First period, small and medium-sized organizations: National Study of Small and Medium-Sized Physician Practices (NSSMPP)

The National Study of Small and Medium-Sized Physician Practices (Rittenhouse et al. 2011) was a forty-minute cross-sectional telephone survey conducted between July 2007 and March 2009 with the lead physician or lead administrator of a national sample of physician practices that had 1–19 physicians. Respondents were paid $175 for their time.

Survey Sample. No publicly available database of US physician practices exists. A comprehensive private database, the IMS Healthcare Organization Services database (IMS Health Incorporated 2012a), was used to create the population from which practices were sampled. In 2007, this national database, updated daily, included 793,235 US physicians linked to the practices in which they work. IMS data are widely accepted and have been used in dozens of studies published in peer-reviewed journals (Nyweide 2009; IMS Health Incorporated 2010b; Casalino 2010).

Practices were eligible for the survey if they had 1–19 physicians of whom at least 60 percent were some combination of adult primary care providers (family physicians, general internists, and general practitioners), cardiologists, endocrinologists, and pulmonologists. Only practices with these specialties were included, because the survey focused on care management processes for preventive care and for four major chronic illnesses: asthma, congestive heart failure, diabetes, and depression. Hospital-owned practices were included, but academic faculty practices were not.

The National Study of Small and Medium-Sized Physician Practices was intended to provide data that would be as nationally representative as possible and that would also be useful for program evaluation purposes in fourteen sites involved in the Aligning Forces for Quality (AF4Q) initiative, sponsored by the Robert Wood Johnson Foundation (Painter and Lavizzo-Mourey 2008). Sites consisted of a range of geographic areas, including states such as Maine, and metropolitan areas such as Cleveland (AF4Q website).

Using the IMS database and the eligibility criteria described above, a random sample of practices was drawn, stratifying by practice size (1–2, 3–8, 9–12, and 13–19 physicians), each of the four specialty types listed above, and location (each of the fourteen Aligning Forces for Quality sites and the remainder of the United States). The strata that had relatively few practices were over sampled, such as single-specialty pulmonology practices with 13–19 physicians. Practices within each of the Aligning Forces for Quality sites were also oversampled, to ensure an adequate sample for evaluation.

The number of practices that responded to the survey was 1,744 (1,200 from the fourteen Aligning Forces for Quality communities and 544 from the national sample). The overall adjusted response rate was 63.2 percent (64.3 percent for the Aligning Forces for Quality communities and 61.3 percent for the national sample) (AAORP 2009). Additionally, relatively few differences were found between responders and non-responders, by practice size and specialty mix. This, along with the survey's relatively high response rate, helps to minimize concerns about non-response bias (**Appendix A**).

Second period: National Study of Physician Organizations, third round (NSPO3)

The NSPO3 was a forty-minute phone survey conducted beginning January 2012 and remains ongoing. The survey was conducted with a lead physician or lead administrator of each organization in a national sample of physician practices and medical groups. Respondents were paid $200 for their time.

Survey Sample. The survey focused on organizational characteristics, care management practices, and related variables for four major chronic illnesses: asthma, coronary heart failure, depression, and diabetes. Thus, an organization was eligible for participation only if a significant percentage of its employed physicians were some combination of adult primary care providers (family physicians, general internists, and general practitioners), cardiologists, endocrinologists, and pulmonologists. Large medical groups of at least 20 physicians were eligible if any combination of these specialties made up at least 30% of their practice while medical groups with fewer than 20 physicians were included if they had 40% of such physicians. Academic faculty practices and medical groups associated with federal hospitals were excluded.

The sample was constructed with the purpose of providing data that would be as nationally representative as possible and would also be useful for program evaluation purposes in each of the seventeen communities across the country participating in the Aligning Forces for Quality (AF4Q) initiative sponsored by the Robert Wood Johnson Foundation. Medical groups who had responded to earlier surveys involving the National Study of Physician Organizations II (NSPO2) and the National Study of Small and Medium-sized Physician Practices (NSSMPP) were re-contacted and asked to respond to the survey. An additional population from the private, comprehensive IMS Health (Danbury, CT) database received in May 2012 was also again created. This national database included 426,514 US physicians linked to the practices in which they work.

Using the IMS database and the eligibility criteria described above, a random sample of practices was drawn, stratifying by practice size (1-2, 3-7,8-12, 13-19, or more than 20 physicians), mix of specialties (primary care, cardiology, endocrinology, pulmonology, and multi-specialty), and location (each of the seventeen AF4Q sites and the remainder of the United States).

The total sample size from all three sources (NSPO2, NSSMPP, and IMS) was 3,045. Of these, 1,161 responded to the survey, and 578 were deemed ineligible for various reasons, resulting in an adjusted response rate of 43.6 percent, as of March 12, 2013.

In comparison to prior NSPO surveys, this rate is relatively low, raising concerns that only those organizations whose values and activities corresponded most with the questions asked in the survey responded. Moreover, practices with 13-99 physicians were less likely to respond to the survey than others, as were cardiology practices (**Appendix A**). In particular, because the survey focuses on the management of chronic illness, it is possible that respondents to the study will be systematically more interested in technologies and processes related to chronic disease management than other organizations, including health information technology. Because of this, to the extent that the survey respondents were not entirely representative of all organizations in the US, estimates of the adoption of health information technology may be positively biased.

Area resource file

The Area Resource File (ARF) is a collection of data from more than 50 sources, released regularly by the Health Resources and Services Administration (HRSA), a branch of the U.S. Department of Health and Human Services. The ARF includes information on the US health care delivery system and factors that may impact health status and health care in the U.S. (Area Resource File 2011-2012). County-level indicators of physicians per capita and hospital counts for the years 2006 and 2008 were drawn from this file.

Office of Management and Budget file of county rural and urban continuum codes

The US Office of Management and Budget (OMB) publishes a file placing counties into nine categories taking into consideration the county's population, whether the county is a metropolitan or non-metropolitan area, and characteristics of adjacent counties (United States Department of Agriculture 2012). This file was used to determine whether practices were located in metropolitan or non-metropolitan areas.

3.3. Measures of health information technology

Analysts have often looked at the adoption of HIT or EHRs as a binary outcome, where practices either use paper records or do not. However, as with many innovations, health information technology is a multifaceted concept. The functionalities of different HIT and EHR systems vary significantly from one-another, and have become markedly more complex and nuanced over time (Brailer 2012). Thus, as Westphal et al. (1997: 367) discuss, when studying innovations, it is often "more appropriate to explore how organizations define and implement an innovation, rather than simply to predict whether organizations adopt at all."

Two key studies have operationalized HIT in a manner reflecting this complexity. One study by a team centered at Harvard's Institute for Health Policy (DesRoches et al. 2008; Rao et al. 2011) located the functions of HIT under four domains: Health information and data; Order-entry management; Results management; and Clinical decision support. Using a slightly broader definition of health information technology, Robinson and colleagues (2009) placed HIT in to seven domains: (1) Electronic documentation; (2) Clinical decision support; (3) Electronic registries for chronic illness; (4) Quality measurement; (5) Electronic access to clinical data; (6) Physician order entry; and (7) Electronic connectivity for patients.

Following the broader set of functionalities used by Robinson and colleagues (2009), this analysis includes 18 HIT functionalities placed under seven domains of HIT (**Table 2**). Although not comprehensive of all functions served by HIT systems, these 18 items represent a broad set of functions, including those typically served by electronic health records, registries for population management, and interoperability between healthcare organizations. To confirm that the rates of adoption captured in the three National Studies of Physician Organizations are valid, **Appendix B** compared rates of the adoption of electronic health records in each survey round with other national surveys of physicians fielded in similar periods. Estimates from the surveys used in this dissertation were generally consistent with estimates from other surveys.

Constructing indices of health information technology functionalities

In order to measure the overall adoption of physician organizations, the 18 items will be combined into an "overall HIT index" (**Table 2**). Additionally, using the two approaches discussed in section 2.4, items were also aggregated into sub-indices. First, reflecting the

"theoretical approach," items will be divided into two indices: an "Internal HIT Index" containing the internal HIT functionalities and an "External HIT index" containing the HIT functionalities enabling information exchange. Specifically, the Internal HIT Index will contain the functionalities in the domains for electronic documentation, clinical decision support, electronic registries for chronic illness, and quality measurement; the External HIT Index will contain the functionalities in the domains for electronic access to clinical data, physician order entry, and electronic connectivity for patients.

Table 2: Functionalities included in health information technology indices

	HIT indices					
	Overall	Internal	EHR	Registries	External	Inter-operability
Ambulatory care progress notes	Y	Y	Y			
List of patient medications	Y	Y	Y			
Problem list	Y	Y	Y			
Alerts for potential drug interactions	Y	Y	Y			
Alerts for abnormal test results	Y	Y	Y			
Prompts at time of patient visit	Y	Y	Y			
EHR used to measure quality	Y	Y	Y			
Registry: Diabetes	Y	Y		Y		
Registry: Asthma	Y	Y		Y		
Registry: Congestive heart failure	Y	Y		Y		
Registry: Depression	Y	Y		Y		
Physician electronic prescribing	Y				Y	
Laboratory test results	Y				Y	Y
Emergency department notes	Y				Y	Y
Hospital discharge summaries	Y				Y	Y
EHR connects to EHR at main hospital	Y				Y	
Physicians use e-mail with patients	Y				Y	
Patients can access part of EHR online	Y				Y	

Second, reflecting the data driven approach, sub-indices were developed by identifying functionalities that commonly were adopted together. To do this, inter-item correlations among the HIT functionalities in the 2006 data, the 2008 data and the 2012 data were examined (**Tables 3a, 3b, and 3c**). These correlations suggested that additional sub-indices existed beyond those identified conceptually. In particular, seven items consistent with the adoption of electronic health records all showed correlations of 0.50 and higher in all three surveys: ambulatory notes, medication lists, problem lists, alerts for drug interactions, alerts for irregular tests, prompts/reminders during visit, and EHR used to collect quality data. The four functionalities for chronic disease registries also showed strong inter-item correlations. Likewise with three of the externally oriented functionalities: laboratory tests, emergency department notes, and hospital discharge summaries. These patterns were very similar across each of the three surveys.

Table 3a: Correlations, adoption of HIT functionalities be medical groups in 2006

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
(1)	Ambulatory care progress notes	1.00																	
(2)	List of patient medications	0.84	1.00																
(3)	Problem list	0.84	0.95	1.00															
(4)	Alerts for potential drug interactions	0.73	0.80	0.81	1.00														
(5)	Alerts for abnormal test results	0.68	0.71	0.72	0.68	1.00													
(6)	Prompts at time of patient visit	0.64	0.69	0.67	0.68	0.65	1.00												
(7)	EHR used to measure quality	0.73	0.73	0.73	0.62	0.53	0.56	1.00											
(8)	Registry: Diabetes	0.17	0.19	0.20	0.14	0.21	0.18	0.26	1.00										
(9)	Registry: Asthma	0.14	0.15	0.17	0.15	0.22	0.26	0.17	0.65	1.00									
(10)	Registry: Congestive heart failure	0.25	0.23	0.24	0.23	0.19	0.27	0.33	0.60	0.69	1.00								
(11)	Registry: Depression	0.17	0.16	0.18	0.16	0.26	0.25	0.19	0.51	0.68	0.63	1.00							
(12)	Physician electronic prescribing	0.44	0.48	0.50	0.54	0.43	0.45	0.43	0.18	0.15	0.17	0.17	1.00						
(13)	Laboratory test results	0.43	0.45	0.43	0.39	0.37	0.34	0.42	0.15	0.07	0.18	0.08	0.19	1.00					
(14)	Emergency department notes	0.43	0.42	0.41	0.34	0.34	0.29	0.42	0.17	0.09	0.17	0.12	0.24	0.52	1.00				
(15)	Hospital discharge summaries	0.43	0.44	0.42	0.39	0.34	0.32	0.44	0.12	0.08	0.23	0.14	0.28	0.67	0.69	1.00			
(16)	EHR connects to EHR at main hospital	0.54	0.53	0.55	0.46	0.45	0.39	0.51	0.18	0.13	0.19	0.13	0.31	0.37	0.68	0.53	1.00		
(17)	Physicians use e-mail with patients	0.26	0.24	0.25	0.22	0.23	0.24	0.25	0.13	0.15	0.14	0.12	0.16	0.20	0.22	0.25	0.25	1.00	
(18)	Patients can access part of EHR online	0.29	0.29	0.30	0.35	0.28	0.37	0.31	0.21	0.23	0.23	0.23	0.31	0.15	0.19	0.19	0.28	0.20	1.00

Notes: N=321 medical groups. The shading in the above and below correlation matrix reflects the strength of the inter-item correlations. Data source: National Study of Physician Organizations II.

Table 3b: Correlations, adoption of HIT functionalities by physician practices in 2008

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
(1)	Ambulatory care progress notes	1.00																	
(2)	List of patient medications	0.89	1.00																
(3)	Problem list	0.90	0.92	1.00															
(4)	Alerts for potential drug interactions	0.68	0.70	0.71	1.00														
(5)	Alerts for abnormal test results	0.66	0.65	0.67	0.65	1.00													
(6)	Prompts at time of patient visit	0.67	0.66	0.68	0.61	0.66	1.00												
(7)	EHR used to measure quality	0.60	0.63	0.65	0.63	0.48	0.61	1.00											
(8)	Registry: Diabetes	0.16	0.14	0.16	0.13	0.14	0.19	0.29	1.00										
(9)	Registry: Asthma	0.11	0.08	0.11	0.12	0.10	0.16	0.22	0.67	1.00									
(10)	Registry: Congestive heart failure	0.15	0.13	0.14	0.14	0.11	0.12	0.26	0.68	0.64	1.00								
(11)	Registry: Depression	0.02	0.01	0.02	0.03	0.06	0.09	0.14	0.62	0.58	0.61	1.00							
(12)	Physician electronic prescribing	0.42	0.45	0.44	0.45	0.37	0.34	0.35	0.08	0.08	0.06	-0.01	1.00						
(13)	Laboratory test results	0.13	0.10	0.10	0.07	0.10	0.12	0.12	0.11	0.09	0.10	0.10	0.04	1.00					
(14)	Emergency department notes	0.02	0.00	0.03	0.02	0.02	0.04	0.01	0.01	0.01	0.01	0.04	0.06	0.39	1.00				
(15)	Hospital discharge summaries	0.11	0.10	0.11	0.12	0.07	0.10	0.07	0.02	0.02	0.03	0.06	0.11	0.39	0.82	1.00			
(16)	EHR connects to EHR at main hospital	0.31	0.32	0.34	0.29	0.38	0.30	0.33	0.07	0.12	0.06	0.10	0.17	0.12	0.11	0.13	1.00		
(17)	Physicians use e-mail with patients	0.03	0.05	0.10	0.06	0.00	0.05	0.02	0.07	0.03	-0.03	0.06	0.06	0.05	0.06	0.04	0.00	1.00	
(18)	Patients can access part of EHR online	0.17	0.21	0.22	0.22	0.27	0.27	0.29	0.04	0.05	0.01	-0.01	0.16	0.06	0.05	0.05	0.16	-0.02	1.00

Notes: N=1,736 physician practices. The shading in the above and below correlation matrix reflects the strength of the inter-item correlations.
Data source: National Study of Small and Medium-Sized Physician Practices.

Table 3c: Correlations, adoption of HIT functionalities by physician practices and medical groups in 2012

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
(1)	Ambulatory care progress notes	1.00																	
(2)	List of patient medications	0.83	1.00																
(3)	Problem list	0.87	0.92	1.00															
(4)	Alerts for potential drug interactions	0.76	0.85	0.82	1.00														
(5)	Alerts for abnormal test results	0.63	0.63	0.64	0.61	1.00													
(6)	Prompts at time of patient visit	0.65	0.66	0.68	0.64	0.62	1.00												
(7)	EHR used to measure quality	0.71	0.75	0.77	0.73	0.58	0.66	1.00											
(8)	Registry: Diabetes	0.30	0.33	0.33	0.33	0.37	0.33	0.40	1.00										
(9)	Registry: Asthma	0.23	0.24	0.24	0.27	0.28	0.27	0.32	0.63	1.00									
(10)	Registry: Congestive heart failure	0.24	0.25	0.26	0.28	0.31	0.28	0.33	0.59	0.66	1.00								
(11)	Registry: Depression	0.17	0.19	0.19	0.20	0.25	0.23	0.25	0.54	0.59	0.58	1.00							
(12)	Physician electronic prescribing	0.49	0.54	0.53	0.50	0.40	0.41	0.46	0.23	0.17	0.19	0.15	1.00						
(13)	Laboratory test results	0.28	0.27	0.27	0.24	0.23	0.24	0.25	0.15	0.11	0.13	0.06	0.29	1.00					
(14)	Emergency department notes	0.14	0.11	0.12	0.12	0.17	0.14	0.17	0.08	0.10	0.14	0.07	0.17	0.44	1.00				
(15)	Hospital discharge summaries	0.16	0.15	0.15	0.16	0.18	0.15	0.18	0.09	0.12	0.16	0.08	0.19	0.49	0.84	1.00			
(16)	EHR connects to EHR at main hospital	0.28	0.28	0.28	0.24	0.30	0.25	0.26	0.18	0.12	0.14	0.16	0.15	0.13	0.25	0.22	1.00		
(17)	Physicians use e-mail with patients	0.14	0.13	0.12	0.11	0.12	0.12	0.12	0.14	0.10	0.09	0.13	0.11	0.04	0.03	0.02	0.06	1.00	
(18)	Patients can access part of EHR online	0.35	0.35	0.37	0.33	0.31	0.30	0.38	0.25	0.21	0.23	0.18	0.23	0.13	0.10	0.10	0.29	0.27	1.00

Notes: N=1,036 physician practices and medical groups. The shading in the above and below correlation matrix reflects the strength of the inter-item correlations. Data source: National Study of Physician Organizations, III (NSPO3).

Exploratory principal components analysis (PCA) and factor analysis were then conducted on each of the three periods, to confirm the internal reliability of the three sub-indices (Furr 2011). Principal components analysis was used to identify the number of strong factors present in the data, and factor analysis was used to confirm the stickiness and attribution of the factors (Furr 2011; Dimitrov 2012). A Scree test (Dimitrov 2012: p81) was used to choose the appropriate number of factors. In each of the three datasets, three factors were identified: one especially strong component and two moderately strong components (**Appendix C: Tables C1, C2, and C3**). In each survey round, the first component accounted for over 30 percent of the eigenvalues, and the second two accounted for around another ten percent.

Factor analysis confirmed that these three factors were attributed as hypothesized following the principle components analysis. For all three surveys, the factor analyses confirmed that one factor showed very high factor loadings for the seven EHR functionalities (all factor loadings were at or above 0.70) (**Appendix C: Tables C4, C5 and C6**). A second factor showed high factor loadings for the four chronic disease registry functionalities (above 0.60 in all three surveys). A third factor represented electronic lab results, ER notes, and, hospital discharge summaries. Thus, following these findings, these three indices were constructed along with those identified through the conceptual process (**Table 2**). Additionally, four functionalities were not associated strongly with other functionalities and thus will be used as measures on their own: (1) connecting the EHR of the physician organization to a hospital EHR; (2) email to patients; (3) patient access to the EHR online; and (4) electronic prescribing. All aggregate measures of health information technology will be "normalized" to be out of a possible 100 points for easier comparison. In total, ten measures of health information technology were used in this study: overall HIT index, internally oriented HIT index, externally oriented HIT index; the three indices from the factor analysis, and the four items that did not load onto a broader measure.

3.4. Key explanatory variables

This subsection discusses the two key sets of external factors hypothesized to effect the adoption of HIT by physician organizations. These variables were the focus of this study because of their promise to inform future policy efforts. Other "external" factors were included to control for contextual factors that may be correlated with, for example, ownership status or affiliation with network-type organizations.

Measures of organizational ties

Dependence on external entities may result in organizations adopting HIT, to the extent it is desired by those entities. This study considers three types of external entities with which many physician organizations frequently interact: hospitals, health plans, and network organizations such as independent practice associations (IPAs) and physician hospital organizations (PHOs). To the extent that hospitals, healthcare systems and HMOs are adopting HIT, they may also ask physician practices owned by them to adopt HIT; thus one variable captured whether organizations were owned by hospitals, healthcare systems, or HMOs, as opposed to operating as an independent practice or other entities, including jointly owned practices, practices owned by non-physician managers, or practices run as non-profit

organizations. To account for the effect of involvement with IPAs/PHOs, a binary indicator captured whether practices reported receiving "a significant amount of their patients" from IPAs or PHOs.

Measures of direct and indirect incentives

Both direct and indirect incentives have been associated with the adoption of HIT in prior studies (Robinson et al. 2009; Williams 2010). The measure of direct incentives is a binary measure capturing whether organizations had the opportunity to receive bonus income based on their adoption or use of HIT. A limitation of this measure is that there may have been great heterogeneity in the strength of incentives faced by different organizations, which may attenuate any true effects.

Two measures of indirect incentives were also included. A general pay-for-performance index (range: 0–2) was created based on whether the practice had the opportunity to receive additional income from external entities based on clinical quality scores and the efficient use of resources. A public reporting index (range: 0–2) was also created for each practice based on whether health plans publicly report practice data on patient satisfaction and clinical quality.

3.5. Control variables

Controlling for factors that might be associated with the treatment of interest (organizational ties and incentives) and/or the outcome minimizes bias and ensures that models are not mis-specified (Wooldridge 2006, ch3). Building off of prior literature, this analysis includes the following control variables.

Measures of organizational characteristics

Organizational size, measured by the number of physicians, will be included as a continuous variable. Because the relative cost (per physician) of implementing HIT is likely much smaller for larger practices relative to smaller practices, it was hypothesized that larger practices will be more likely to have adopted HIT (DesRoches et al. 2008; Gans et al. 2005; Robinson et al. 2009). A logged term will be used to capture diminishing returns to increased organizational size. Organizational specialty composition is examined using three categories: all primary physicians, all specialty physicians (including endocrinology, pulmonology and cardiology specialties), and multi-specialty practices including primary care and specialty physicians. Specialty composition may affect the kind of HIT system purchased and the availability of systems that provide functionalities needed by all specialties. When available, the proportion of patients seen by each organization that were non-white was also controlled for, as a potential proxy for the wealth of organizations' clients, and also to see whether minority patients receive care from less technologically advances organizations.

Indicators of organizational interest in improving quality of care may also be associated with the adoption and use of HIT (Institute of Medicine 2001). To capture this, a "patient-centered management" index was constructed, adapted from the National Malcolm Baldrige Quality Award criteria, using the following items: practice assesses patient needs; staff promptly resolve patient complaints; patients' complaints are studied to identify patterns and prevent reoccurrence; practice uses data from patients to improve care; and practice uses data on patient satisfaction when developing new services (US Department of Commerce 2007;

Rittenhouse et al. 2010; Shortell et al. 2004). Practices answered each on a scale of 1 (strongly disagree) to 5 (strongly agree). To capture the extent to which practices placed an especially strong emphasis on these items, the index was constructed such that one point was given for each item only when respondents answered "strongly agree" to that item. The resulting "patient-centered management" scale thus has a range from 0-5 (Rittenhouse et al. 2011). Additionally, whether organizations participate in quality improvement programs or use plan-do-study-act quality improvement strategies was also included, as indicators of how concerned the organizations were about the quality of care they provided.

Organizational revenue sources were also analyzed, including the percentage of annual revenue patient care from each of the following sources: Medicare, Medicaid, uninsured, commercial insurance, and other. Because commercial insurers are typically much more generous than Medicare and Medicaid, organizations' payer mix may control, to some extent, for organizations' ability to access financial capital. Additionally, because adjustments Medicare physician fee schedules based on use of HIT of up to five percent to will begin in 2015 (Centers for Medicaid and Medicaid Services 2011), providers acquiring much of their revenue from Medicare may be more inclined to implement HIT systems than those not relying on Medicare as a major revenue source.

Measures of healthcare markets

Healthcare markets vary greatly in their composition (Baker 2001), including the density and distribution of physicians, hospitals, insurers, and many other actors in the healthcare sector. These factors influence the cost of healthcare (e.g., Baker 1997; Baker et al 2012; Robinson 1991) and how organizations compete in healthcare markets (Robinson and Casalino 1996; Casalino, Devers, and Brewster 2003). For example, after experiencing increased revenue and cost pressures stemming from the rise of managed care in the 1990s, many physicians reacted by shifting the mix of services provided (Pham et al. 2004) and, in some cases, the kinds of organizations in which they provided services (Casalino, Devers, and Brewster 2003).

Market factors may potentially also affect the adoption of health information technology and other innovations. As Abrahamson and Rosenkopf (1993) discuss, organizations in more competitive markets may feel pressures to adopt innovations "arising from the threat of lost competitive advantage" (Abrahamson and Rosenkopf 1993). While a handful of studies on physician organizations have looked at the effect of external factors on the adoption of HIT, the metrics used have been limited in their operationalization of competition. To date, the only national study on the adoption of HIT by physicians measured competition according to self-reported perceptions (Menachemi et al. 2012). Thus, three measures of healthcare markets were included: (1) the number of physicians per capita; (2) HMO penetration rates; and (3) the prevalence of hospitals in the region.

First, the number of physicians per capita in an area is a standard metric of physician supply (Goodman 2004). In areas where physician supply is relatively higher, and thus the competition relatively stiffer, physician organizations may be more likely than others to make investments in HIT in order to differentiate themselves to patients and other healthcare organizations. Physician organizations might also use HIT to connect with hospitals' or other organizations' HIT systems, in an effort to solidify their position as a preferred partner (Skolnik et al. 2011: 21) or to join an Accountable Care Organization or other joint partnerships requiring

information exchange. Thus, a metric of physicians per capita at the county level was included, using data from the Area Resource File (Area Resource File 2009). The parameter was calculated by dividing the number of physicians in each area by the number of persons in each county, was expressed in terms of physicians per 1000 persons (Goodman 2004).

Second, cost pressures from health maintenance organizations (HMOs) may also result in increased sensitivity to competition with other physician organizations. Over the 1980s and 1990s, HMOs cut costs in response to increased competition (Wholey et al. 1997; Kronebusch, Schlesinger and Thomas 2009), leading physician organizations to constrain their utilization of resources and search for new ways to improve outcomes (Wholey et al. 1997). Prior studies have found that physician organizations in areas with greater enrollment of patients in HMOs were more likely to adopt care management processes (Casalino et al. 2003; Shortell et al. 2001) and HIT (Menachemi et al. 2012). Thus, this analysis also included a measure of HMO penetration – the percentage of residents enrolled in health management organizations at the state-level, using data from Healthleaders, Inc (Kaiser Family Foundation, State Health Facts, 2011).

Third, the prevalence of hospitals in a region may influence the willingness of physician organizations to adopt health information technology. Hospitals and physician organizations are often financially intertwined, and because of that, hospitals often have influence the financial decisions of physician organizations (Shortell 1991). However, hospitals may have less influence over physician organizations when organizations have more choice in the hospitals with which they associate; as suggested by resource dependence theory (Pfeffer and Salancik 1978), when possible, rather than bend to the demands of a particular hospital (e.g., by purchasing the hospital's preferred electronic health record software), a physician organization might choose instead to shift business to another hospital. Thus, physician organizations in regions with relatively more hospitals are hypothesized to be less likely to adopt HIT, since their ability to choose among hospitals will increase their autonomy in deciding whether to adopt HIT. This measure was constructed using county-level counts of hospital, accessed from the Area Resource File (2009-2010).

However, a limitation of these three measures of healthcare market is that they may not capture the set of resources or constraints most salient to the physician organizations in the study (Menachemi et al. 2012). Nonetheless, because of the clear conceptual relevance, the indicators are kept as control variables.

Measures of population density

Organizations in rural areas may adopt HIT less than other organizations for several reasons. Perhaps primarily, controlling for other factors, organizations in rural areas may have relatively less access to financial resources than others (Singh et al 2012). Additionally, relative to organizations in more densely populated areas, physician organizations located in rural areas face less competition; their physicians may be less educated about the potential benefits of adopting HIT; and both physician organizations and their patients may have less access to broadband internet, with which they would be more likely to take advantage of the ability to access their patient records online.

Thus, an indicator of low population density was included in this study. Specifically, the US Office of Management and Budget (OMB) has developed a standardized approach to

capturing the "urbanicity" of an area. They placed counties into nine categories taking into consideration the county's population, whether the county is a metropolitan or non-metropolitan area, and characteristics of adjacent counties (USDA 2012).

For this study, these nine OMB categories were combined into two groupings: (1) metropolitan counties of any size (typically very populated areas) and (2) non-metropolitan counties. More detailed categories would have been used, but relatively few physician organizations were surveyed in non-metropolitan counties, making further stratification difficult.

3.6. Analytical plan

This study aimed to examine the association between the adoption of HIT in 2006/2008 and 2012 and external and organizational factors.

Descriptive statistics

First, summary statistics were examined, for: (1) the individual HIT functionalities, (2) the HIT indices, and (3) the explanatory variables used in the study. In each of these three sets of variables, summary statistics were examined in two ways: (1) for each cross-section of the survey data, by whether organizations responded to both waves of the surveys or just one; and (2) by survey period, for organizations in the panels that responded to both waves of the surveys. The first set of descriptive statistics shows to what extent the "panel" organizations were similar to organizations responding to only one survey wave; the second set shows mean changes in variables over time for organizations in the panels.

Additionally, in order to develop profiles of non-adopting organizations vs. those adopting early and late, summary statistics were also presented for organizational and external characteristics, stratified by whether organizations had: (1) adopted any electronic health record functionalities in 2006/2008, (2) adopted any electronic health record functionalities in 2012, or (3) never adopted any electronic health record functionalities. Two sets of t-tests were used to examine differences between those adopting by 2012 (but not earlier) – the "later" adopters – with those not yet adopting and those adopting by 2006/2008. Of note, although it is possible that many practices in the "non-adopters" set may adopt soon, this cannot be observed, because information on decisions made in the future is obviously currently unavailable. Thus, these bivariate analyses effectively place "non-adopters" and "later adopters" into the same group.

Multivariate models

Following this exploratory analysis, regression analysis was used to examine associations between key factors and the adoption of HIT, while also accounting for controls. Regressions were divided into three sets, to explore factors associated with early adoption, later adoption, and non-adoption. Each regression model discussed below was run for each of ten metrics of HIT, including the overall HIT index, five sub-indices, and four functionalities that did not load onto any sub-indices (Physician electronic prescribing, Physicians use e-mail with patients, and Patients can access part of EHR online).

The first set, focusing on factors associated with early adoption, employed cross-sectional regression using baseline 2006/2008 data (t=1) to capture factors associated with the

adoption of HIT by "early adopters." In these regressions, the dependent variables were the overall HIT index and sub-indices, and independent variables were levels of factors at baseline (in 2006/2008). For the small physician practices, standard errors were clustered within the Aligning Forces for Quality community sites, to account for the complex sampling frame of the survey used to collect those responses.. For the large medical groups, Huber-White "robust" standard errors were used to account for heteroscedasticity (Wooldridge 2006); standard errors for this group were not clustered, because the sampling frame was not stratified by region. This model was specified as:

(1) $HIT_{i,t=1} = f(OrgTies_{i,t=1}, Incentives_{i,t=1}, MktFctrs_{j,t=1}, RuralLoc_{j,t=1}, OrgChars_{i,t=1})$,

where:

i = physician organization
j = county/regional market area
t = time,

and additionally:

OrgTies = a vector of variables indicating organizational ties
Incentives = a vector of direct and indirect incentives
MktFctrs = a vector of indicators for the competitiveness of regional markets
RuralLoc = a measure of whether counties were classified as non-metropolitan
OrgChars = a vector of organizational characteristics.

The second set of regression models exploited the panel data structure to identify factors associated with changes in the adoption of HIT between the first and second survey periods. To capture this, the fixed effects regression approach was used to account for the repeated observations of organizations over time, because the Hausman test (Hausman 1978) rejected the validity of random effects models in this case. In particular, an extension of the fixed effects model was used, in which a change in the adoption of HIT was modeled as a function of interaction terms – explanatory variables interacted with a period dummy effect ("Year 2012") – in addition to the usual specification of the explanatory variables (Allison 2009). In contrast to the standard fixed effects approach, in which changes in an outcome are modeled as a function of changes in explanatory variables (Hausman and Taylor 1981), the inclusion of period interaction effects allowed for the models to explicitly test the extent that the relationship between each factor and an outcome changed over time, between the two periods (Allison 2009; Menachimi et al. 2011).

This model was the most appropriate analytic approach for this case, because the relationships between key explanatory factors (e.g., organizational ties, incentives, and market factors) and the adoption of HIT were hypothesized to diminish in magnitude as other unobserved environmental pressures to adopt HIT (e.g., meaningful use incentives, improved technology, and better information about the benefits of HIT, etc.) increased over time between 2006/2008 and 2012. These factors, to which all physician organizations in the United States were exposed, were hypothesized to affect all organizations to some extent, thereby moderating the magnitude of the explanatory factors relative to the model for early adoption.

For example, hospital-owned organizations may have been more likely to adopt HIT relative to independently-owned organizations in both periods, but the effect of hospital ownership may have been stronger for early adoption than for later adoption, because of the new environmental pressures that potentially "raised the tide [of information technology] for all boats." The fixed effects model including period interaction terms allows for this hypothesis to be directly tested, by examining whether the relationships between explanatory factors and the adoption of HIT actually diminished over time.

Moreover, as with the standard fixed effects approach, this approach also conservatively estimates effects on the adoption of HIT, because the fixed organizational effects restrict the analysis to using only variation coming from within each organization, thereby nullifying concerns that any perceived effects resulted from time-consistent omitted variables.

This model was specified as:

$$(2) \quad HIT_{i,t} = f(Yr12_{t}, OrgTies_{i,t}, Incentives_{i,t}, OrgChars_{i,t}, OrgTies*Yr12_{i,t}, Incentives*Yr12_{i,t}, OrgChars*Yr12_{i,t}, MktFctrs*Yr12_{j,t}, RuralLoc*Yr12_{j,t}, \alpha_{i}),$$

where:

Yr12 represents a survey year dummy variable,

α_{i} signifies organizational fixed effects.

Because this model included more than one observation from each organization, standard errors were clustered at the organizational level. Market factors and rural location were included only with year interaction terms, because they were not time-varying at the organizational level (Snowden et al. 2008).

Additionally of note, the model is interpreted slightly differently from the standard fixed effects model (Robinson and Phibbs 1989). Parameters without interactions represent effects on changes in HIT at baseline, while parameters with interactions represent the difference in the effects between the second and first periods (e.g., how the relationship changed between each explanatory variable and the adoption of HIT over time) on changes in HIT.

Generalizability

Because weights were not available for the second period of the data, no weights were used in the above models. This limits the generalizability of these results; while organizations in the sampling frame were selected from a population of physician organizations at the national-level, some kinds of physician organizations were much more likely to be selected than others (e.g., because there are fewer medium-sized endocrinology practices than small primary care practices, each small primary care practice in the US was much less likely to be selected in the sampling frame than each medium-sized endocrinology practice).

Hypothesis testing

Each of the hypotheses identified in the second chapter will be tested empirically based on results from the above linear regression models. In all, 40 models were run – ten dependent

variables x two models x two panels of organizations (for small/medium-sized practices and large medical groups). Because of this, it is important to specify which parameters from which models will be required to support specific hypotheses.

For hypothesis **H1**, parameters from the hospital/system/HMO ownership variable were examined on models of early adoption (model 1), for all ten of the measures of HIT; the hypothesis would be supported if parameters were consistently positive and statistically significantly different from zero with at least 95% confidence. Hypothesis **H1a** additionally proposed that organizational ties would have an especially strong association with the adoption of "externally oriented" functionalities enabling health information exchange, as measured by the interoperability index, electronic prescribing, connecting with the EHR of the main hospital, email to patients and enabling patients to access their EHR online. This hypothesis would be confirmed to the extent that the association between organizational ties and health information exchange functionalities was substantially greater than the association between organizational ties and internally oriented functionalities across all time periods. Hypothesis **H1b** proposed that the strength of hospital/system/HMO ownership would diminish over time. This was confirmed by examining whether the interaction terms from model (2) were significantly less than zero.

Hypothesis **H2** was tested using an approach similar to **H1**, but for the variable capturing affiliation with an independent practice association or physician hospital organization. Likewise, hypothesis **H2a** would be confirmed if the interaction term in the second set of models were significantly different from zero. Unlike for the ownership parameter, there was no strong hypothesis about the dependent variables for which IPA/PHO affiliation would operate most strongly.

Hypothesis **H3** proposed that organizations facing direct incentives from external entities for the adoption or use of HIT will be more likely to have adopted HIT, overall, than other organizations. To test this, the parameter for reporting the opportunity to receive bonus income for the adoption or use of HIT was examined in the first set of models. Additionally, under **H3a**, the effect on the adoption of HIT from direct incentives were hypothesized to diminish in strength over time, which was confirmed by examining the interaction terms from model (2).

Finally, **H4** suggested that indirect incentives, as measured by public reporting, and the opportunity to receive bonus income for quality/efficiency, would be associated with the adoption of HIT in the first model. As above, **H4a** posted that the effect of indirect incentives would wane over time, which was tested through examining the interaction terms from the second set of models.

4A. RESULTS: SMALL AND MEDIUM-SIZED PHYSICIAN PRACTICES

4A.1. Summary of the chapter

This sub-chapter discusses results for the sample of small and medium-sized physician practices. In the first two sections, summary statistics are discussed, followed by three sections discussing multivariate results. A final section summarizes the extent to which support for hypotheses was found.

4A.2. Patterns in the adoption of health information technology

Adoption rates of functionalities

The rate of small and medium-sized physician practices adopting health information technology (HIT) functionalities varied substantially across functionalities and over time. Among the 720 physician practices responding to two rounds of the National Study of Physician Organizations (first survey fielded: 7/2007-3/2009; second survey fielded: 1/2012-ongoing, with data extracted 3/2013), levels of adoption in the first period ranged from 1.4 percent of all practices reporting that patients could access part of the EHR online to 80.8 percent reporting they could electronically view laboratory test results (**Table 4a**). Between the two periods (2008 and 2012), rates for all but one functionality – emergency department notes – increased at levels statistically significant from zero. Electronic prescribing, and several electronic health record functionalities showed the greatest increases in rates of adoption over time. As expected, functionalities with especially high levels of adoption in 2008 (laboratory tests, emergency department notes and hospital discharge summaries had adoption rates of over 75 percent in 2008) showed the lowest increases in adoption rates over time. Additionally, while adoption rates of most functionalities hovered around or above 50 percent in 2012 for small and medium-sized physician practices, the adoption of some functionalities still remained less common. Only 16 percent of physician practices had adopted the ability to connect their EHR to their main hospital's EHR. Use of email to communicate with patients and the ability of patients to access part of their EHR online also remained at or under 20 percent. A third or fewer of practices had adopted each of the functionalities for chronic disease registries.

In comparing rates of the adoption of HIT functionalities between the cohort of practices responding to both rounds of the survey and practices responding to only one round, very few differences were found (**Table 5a**). Rates of adoption differed between practices responding to one survey and both surveys for only a single functionality: connecting to the practice's EHR to that of their main hospital, in 2008, a rather small but significant difference of three percentage points. This suggests that the practices in the cohort were similar to those only responding once, which provided support to the generalizability of the cohort and relieved concerns about selection bias.

Table 4a: Adoption of HIT functionalities by small and medium-sized physician practices responding to both surveys, 2008 and 2012

	National survey of small and medium sized practices (2008), % n=(720)	National survey of physician organizations III (2012) , % n=(720)	P-value	Difference, mean %
Ambulatory care progress notes	29.6	60.8	**0.000**	31.3
List of patient medications	33.3	68.2	**0.000**	34.9
Problem list	31.3	65.6	**0.000**	34.3
Alerts for potential drug interactions	24.4	61.7	**0.000**	37.2
Alerts for abnormal test results	21.1	48.5	**0.000**	27.4
Prompts at time of patient visit	19.4	49.7	**0.000**	30.3
EHR used to measure quality	24.0	56.7	**0.000**	32.6
Registry: Diabetes	22.8	33.2	**0.000**	10.4
Registry: Asthma	12.6	25.6	**0.000**	12.9
Registry: Congestive heart failure	14.9	22.8	**0.000**	7.9
Registry: Depression	9.7	17.1	**0.000**	7.4
Physician electronic prescribing	32.8	78.9	**0.000**	46.1
Laboratory test results	80.8	87.1	**0.000**	6.3
Emergency department notes	74.9	75.6	0.697	0.7
Hospital discharge summaries	75.1	79.3	**0.016**	4.2
EHR connects to EHR at main hospital	8.6	16.3	**0.000**	7.6
Physicians use e-mail with patients	12.6	17.4	**0.001**	4.7
Patients can access part of EHR online	1.4	19.9	**0.000**	18.5

Note: The p-values were derived from t-tests comparing levels of adoption in the first and second survey periods. Abbreviations: EHR electronic health record; HIT, health information technology.

Indices of health information technology functionalities

As with the individual functionalities, the levels of the overall HIT index and sub-indices also increased substantially over time. Among small/medium-sized practices responding to both waves of the survey, the overall HIT index increased by nearly 20 percentage points on average, from an average of 30 percent of all HIT functionalities adopted in 2008 to 50 percent in 2012 (**Table 6a**). Among the sub-indices, the electronic health record index demonstrated the largest increase between the two surveys, of 33 percentage points. By 2012, the average small/medium-sized practice had adopted nearly 60 percent of the EHR functionalities. However, not all indices increased at such a high rate. The registries index increased only nine percentage points, on average; reflecting this, by 2012, over 60 percent of small and medium-sized physician practices had not adopted any registries. Additionally, the interoperability index increased only 4 percentage points, but the functionalities in that index were adopted by a large majority of practices at baseline.

When comparing organizations responding to both rounds of the survey with those responding to only one round, the overall HIT index and sub-index levels did not differ significantly across survey rounds, thereby minimizing concerns about selection bias (**Table 7a**).

Table 5a: Adoption of HIT functionalities by small and medium-sized physician practices, 2008 and 2012

	National survey of small and medium sized practices				National survey of physician organizations III			
	Overall, % n=(1736)	Responded in one round, % n=(1016)	Responded in both rounds, % n=(720)	p-value	Overall, % n=(936)	Responded in one round, % n=(216)	Responded in both rounds, % n=(720)	p-value
Ambulatory care progress notes	29.3	29.0	29.6	0.805	62.0	65.7	60.8	0.187
List of patient medications	33.7	34.0	33.3	0.787	68.9	71.3	68.2	0.381
Problem list	30.5	30.0	31.3	0.584	66.5	69.4	65.6	0.281
Alerts for potential drug interactions	23.6	23.0	24.4	0.496	62.6	65.7	61.7	0.272
Alerts for abnormal test results	20.0	19.2	21.1	0.328	48.6	49.1	48.5	0.877
Prompts at time of patient visit	19.3	19.2	19.4	0.896	50.7	54.2	49.7	0.252
EHR used to measure quality	24.1	24.2	24.0	0.929	57.6	60.6	56.7	0.296
Registry: Diabetes	23.2	23.4	22.8	0.752	32.9	31.9	33.2	0.731
Registry: Asthma	12.7	12.7	12.6	0.971	24.9	22.7	25.6	0.383
Registry: Congestive heart failure	15.4	15.8	14.9	0.574	22.8	22.7	22.8	0.977
Registry: Depression	8.9	8.4	9.7	0.335	17.2	17.6	17.1	0.863
Physician electronic prescribing	30.6	29.0	32.8	0.097	79.5	81.5	78.9	0.396
Laboratory test results	80.6	80.4	80.8	0.827	87.8	90.3	87.1	0.179
Emergency department notes	75.6	76.2	74.9	0.529	75.2	74.1	75.6	0.662
Hospital discharge summaries	75.5	75.8	75.1	0.757	78.6	76.4	79.3	0.372
EHR connects to EHR at main hospital	10.4	11.6	8.6	**0.039**	17.4	21.3	16.3	0.105
Physicians use e-mail with patients	13.0	13.3	12.6	0.692	18.5	22.2	17.4	0.125
Patients can access part of EHR online	2.1	2.7	1.4	0.057	20.7	23.6	19.9	0.25

Note: The p-values for each year signify whether practices responding to both round of the survey differed significantly from those responding to only one round. Abbreviations: EHR electronic health record; HIT, health information technology.

Table 6a: HIT indices for small and medium-sized physician practices, 2008 and 2012

	National survey of small and medium sized practices (2008) n=(720)	National survey of physician organizations III (2012) n=(720)	P-value	Difference, mean
Overall HIT index	29.6	49.5	**0.000**	19.9
Internally oriented HIT index	22.3	46.9	**0.000**	24.6
Electronic health record index	26.2	58.7	**0.000**	32.6
Registries index	15.3	24.7	**0.000**	9.4
Externally oriented HIT index	40.9	53.5	**0.000**	12.6
Interoperability index	76.9	80.6	**0.008**	3.7

Note: The p-values were derived from t-tests comparing levels of adoption in the first and second survey periods. Abbreviations: HIT, health information technology.

Table 7a: HIT indices for small and medium-sized physician practices, 2008 and 2012

	National survey of small and medium sized practices (2008)				National survey of physician organizations III (2012)			
	Cronbach's alpha n=(1736)	Responded in one round, mean n=(1016)	Responded in both rounds, mean n=(720)	p-value	Cronbach's alpha n=(936)	Responded in one round, mean n=(216)	Responded in both rounds, mean n=(720)	p-value
Overall HIT index	0.871	29.5	29.6	0.927	0.897	51.9	49.5	0.236
Internally oriented HIT index	0.905	21.9	22.3	0.780	0.917	49.6	46.9	0.312
Electronic health record index	0.947	25.5	26.2	0.725	0.947	62.3	58.7	0.269
Registries index	0.843	15.4	15.3	0.925	0.867	23.7	24.7	0.740
Externally oriented HIT index	0.569	41.3	40.9	0.683	0.652	55.6	53.5	0.236
Interoperability index	0.691	77.5	76.9	0.760	0.826	80.2	80.6	0.880

The p-values for each year signify whether practices responding to both round of the survey differed significantly from those responding to only one round. Abbreviations: HIT, health information technology.

4A.3. Organizational characteristics and external factors over time

Organizational characteristics and external factors

Turning to the organizational characteristics of the physician practices responding to the surveys and external factors they experienced in each period, the median size (measured by number of physicians) of the practices responding to both the 2008 and 2012 surveys was 3 physicians in both rounds (**Table 8a**). Around 70 percent of the practices were comprised of only primary care physicians and around 80 percent were owned by physicians. The practices reported receiving around 40 percent of their revenue from commercial health plans, and another 35 percent from Medicare. With respect to their orientation towards quality improvement, around 15 percent participated in quality improvement programs; and around 15 percent also reported using plan-do-study-act methods of quality improvement. Finally, only about 12 percent of practices were located in non-metropolitan areas, as classified by the US Office of Budget and Management (USDA 2012).

In the first survey period, practices that responded to both survey rounds were more likely to be owned by physicians and were exposed to a greater HMO penetration rate than one-time responders. In the second period, practices responding to both survey rounds were more likely to be primary care practices, were more likely to report having had the opportunity to receive bonus income for the adoption or use of HIT, and were exposed to a lower HMO penetration rate. Additionally, in the second period, practices responding to both survey rounds were marginally larger than first-time respondents, because a few reported growing in size, in one case by about 200 physicians, thereby bringing up the average significantly. However, the median practice size for each group was exactly the same – three physicians. While these minor differences suggests that practices responding to both survey rounds may differ somewhat from other practices, for the vast majority of variables practices responding to one survey did not differ from those responding in both rounds.

Characteristics of early, late and non-adopters

For small/medium-sized practices responding to both waves of surveys (2008 and 2012), several significant differences stood out among practices adopting any EHR functionalities by 2008 (“early adopters,” n=261), those adopting any EHR functionalities by 2012 (“majority adopters,” n=262), and practices not yet adopting any functionalities by 2012 (“non-adopters,” n=197) (**Table 9a**). In particular, the mean practice size of early adopters (4.9 physicians) was significantly greater than those of majority adopters (3.9 physicians), and the mean practice size of majority adopters was significantly greater than non-adopters (2.3 physicians). (Practices also differed by median practice size.) A similar gradient was seen with participation in quality improvement programs (early: 22%, majority: 16%, non-adopters: 9%), use of plan-do-study-act methods (early: 21%, majority: 10%, non-adopters: 4%), and having the opportunity to receive bonus income for the adoption or use of HIT (early: 26%, majority: 16%, non-adopters: 9%). Majority adopters were also significantly less likely to be owned by physicians than non-adopters (84% vs. 97%). Surprisingly, non-adopters were significantly more likely to be located in metropolitan areas than majority adopters (majority: 13%, late: 6%).

Table 8a: Organizational characteristics and external factors for physician practices, over time, in and out of the panel

	National survey of small and medium sized practices (2008)			National survey of physician organizations III (2012)		
	Responded in one round n=(1016)	Responded in both rounds n=(720)	p-value	Responded in one round n=(216)	Responded in both rounds n=(720)	p-value
Practice size, mean	4.1	3.8	0.137	4.4	7.8	**0.000**
Practice size, median	3.0	3.0		3.0	3.0	
Specialty mix, %						
Primary care	73.4	75.1	0.420	61.1	73.2	**0.001**
Multispecialty	2.3	3.1	0.319	6.0	4.6	0.425
Specialty	24.3	21.8	0.221	32.9	22.2	**0.003**
Minority patients, mean %	28.3	28.6	0.805	34.6	31.1	0.069
Patient-centered management index (0-5), mean	2.2	2.3	0.443	1.8	1.9	0.600
Participated in QI program, %	17.4	16.3	0.520	16.7	20.6	0.188
Used plan-do-study-act, mean	0.1	0.1	0.491	0.1	0.2	0.383
Revenue, mean %						
Medicare	35.4	35.3	0.923	35.5	35.4	0.961
Medicaid	10.1	9.2	0.121	10.2	10.1	0.885
Uninsured	7.3	7.5	0.731	8.7	8.3	0.667
Commercial	41.8	43.1	0.201	39.7	39.9	0.901
Other	5.4	5.0	0.378	6.0	6.4	0.661
Ownership, %						
Physician owned	79.3	86.1	**0.000**	75.5	79.0	0.281
Hospital/system/HMO owned	15.0	8.5	**0.000**	16.7	16.7	1.000
Other	5.7	5.4	0.793	7.9	4.3	0.073
Received patients from an IPA/PHO, %	27.8	27.2	0.806	24.1	19.9	0.198
Public reporting index (0-2), mean	0.65	0.64	0.748	0.77	0.91	**0.039**
Bonus income for quality/efficeincy (0-2), mean	0.63	0.62	0.949	0.67	0.69	0.702
Bonus income for IT, %	15.2	17.6	0.171	14.4	21.8	**0.009**
HMO penetration rate, mean	21.1	22.1	**0.015**	25.4	24.0	**0.036**
Population density, %						
Metropolitan area	86.7	87.9	0.456	88.4	87.6	0.753
Non-metropolitan area	13.3	12.1	0.456	11.6	12.1	0.838

Note: The p-values for each year signify whether practices responding to both round of the survey differed significantly from those responding to only one round. Abbreviations: HMO, health maintenance organization; HIT, health information technology; IPA, independent practice association; PHO, physician-hospital organization; QI, quality improvement.

Table 9a: profiles of physician practices adopting HIT earlier, later, and non-adopters

	Adopted EHR by 2008 n=(261)	Adopted EHR by 2012 n=(262)	Had not adopted EHR by 2012 n=(197)
Practice size, mean	4.9*	4.0	2.3*
Practice size, median	4.0	3.0	1.0
Specialty mix, %			
Primary care	77.4	71.0	77.7
Multispecialty	1.5*	4.6	3.0
Specialty	21.1	24.4	19.3
Minority patients, mean %	26.3*	30.8	28.7
Patient-centered management index (0-5), mean	2.2	2.3	2.3
Participated in QI program, %	21.8	16.0	9.1*
Used plan-do-study-act, %	21.1*	9.9	4.1*
Revenue, mean %			
Medicare	33.6*	36.8	35.6
Medicaid	10.4	10.1	6.2*
Uninsured	7.6	7.6	7.2
Commercial	43.6	40.4	46.0
Other	4.8	5.1	5.1
Ownership, %			
Physician owned	80.5	83.6	97.0*
Hospital/system/HMO owned	11.9	9.5	2.5*
Other	7.7	6.9	0.5*
Health plan index (0-5), mean	2.8	2.7	2.6
Received patients from an IPA/PHO, %	26.8	29.4	24.9
Public reporting index (0-2), mean	0.7	0.6	0.6
Bonus income for quality/efficiency (0-2), mean	0.6	0.7	0.5
Bonus income for IT, %	26.1*	15.6	9.1*
Physicians per 1000 persons, mean	3.3	3.3	3.5
Number of hospitals, mean	8.8*	13.7	13.7*
HMO penetration rate, mean	22.1	21.9	22.4
Population density, %			
Metropolitan area	84.7	86.6	93.9*
Non-metropolitan area	15.3	13.4	6.1*

Note: *p<.05. N=720. Data are baseline data, collected in 2008. The t-tests compare majority-adopters to early-adopters and non-adopters. Abbreviations: EHR electronic health record; HIT, health information technology; HMO, health maintenance organization; IPA, independent practice association; PHO, physician-hospital organization; QI, quality improvement.

4A.4. Association between HIT and organizational ties

Early adoption

Hypothesis **H1** posited that physician organizations owned by a hospital, health system, or HMO would be associated with the early adoption of HIT functionalities. In multivariate cross-sectional analyses, after controlling for other factors, ownership by a hospital/health system/HMO was in fact associated with a 5.2 percentage point increase (95% confidence interval (CI):0.4,10.1) in the adoption of HIT functionalities in 2008 (**Table 10**). This was a relatively large effect when considering that only about 30 percent of all functionalities were adopted at that time, on average.

Table 10: Effect of organizational ties on the adoption of HIT by 2008, small and medium-sized physician practices, results from cross-sectional linear regression

	Ownership: Hospital/ system/HMO (ref: phys.)	Received patients from an IPA/PHO	Adj r-sq.
Overall HIT index	5.214 [0.372,10.055]*	1.849 [-1.377,5.076]	0.174
Internally oriented HIT index	2.666 [-2.977,8.309]	1.050 [-3.397,5.497]	0.170
Electronic health record index	3.016 [-3.116,9.148]	-0.783 [-6.782,5.217]	0.128
Registries index	2.230 [-3.879,8.339]	4.181 [0.992,7.369]*	0.163
Externally oriented HIT index	9.072 [4.750,13.395]**	3.053 [1.431,4.676]**	0.120
Interoperability index	12.147 [7.132,17.163]**	5.648 [2.716,8.580]**	0.114
Electronic prescribing	2.418 [-7.348,12.185]	0.212 [-5.695,6.119]	0.077
EHR connects to EHR at main hospital	17.489 [6.540,28.437]**	5.946 [1.983,9.909]**	0.112
Email	2.849 [-2.526,8.224]	-2.070 [-5.663,1.523]	0.075
Access EHR online	4.309 [0.328,8.289]*	0.340 [-1.284,1.965]	0.028

Notes: +p<0.10; *p<0.05; **p<0.01. N=1736. This table shows results from ten separate regressions; each row represents one model, for which the dependent variable is listed on the left column of this table. All variables shown in descriptive statistics were also included in each model presented above. Standard errors were adjusted to reflect the complex sampling frame of the National Survey of Small and Medium Sized Physician Practices. Abbreviations: EHR electronic health record; HMO, health maintenance organization; HIT, health information technology; IPA, independent practice association; PHO, physician-hospital organization. Data source: National Study of Small and Medium-sized Physician Practices (July 2007 - March 2009).

Additionally, as posited in hypothesis **H1a**, ownership was much more strongly associated with the adoption of externally oriented functionalities than with internally oriented functionalities. While the ownership was associated with a 9.1 percentage point increase in the externally oriented index (CI: 4.8,13.4), a non-significant 2.7 percentage point increase was found in association with the internally oriented HIT index. Notably, the strong positive association with the externally oriented index was not found evenly across measures of HIT, but was driven by the interoperability index (12.1, CI: 7.1,17.2) and connecting the EHR to that of the main hospital (17.5, CI: 6.5,28.4). This is perhaps not surprising, because these two measures are directly relevant to better connecting physician practices with hospitals/health systems, in contrast to other measures that may have been more relevant for patients.

Hypothesis **H2** argued that practices affiliated with an independent practice association (IPA) or physician-hospital organization would also be more likely to have early adopters of HIT. While receiving patients from an IPA or PHO was not significantly associated with the overall HIT index, it was significantly associated with the registries index (4.2, CI: 1.0,7.4), the interoperability index (5.6, CI: 2.7,8.6), and connecting the EHR to that of the main hospital (5.9, CI: 2.0,9.9). Thus, while IPAs and PHOs may not have assisted with the adoption of electronic health records early on, it does appear that they assisted in connecting physician practices to other healthcare organizations.

Later adoption

To recall, in the fixed effects models including time-interacted variables, parameters without interactions represent effects on changes in HIT at baseline, while parameters with interactions represent the shift in the effects between the second and first periods (e.g., how the relationship changed between each explanatory variable and the adoption of HIT over time). With this in mind, hypothesis **H1b** – that the magnitude of the relationship between ownership by a hospital/health system/HMO and the adoption of HIT would diminish over time as pressures for all organizations to adopt HIT grew – was not at all supported (**Table 11**). In fact, examining the Year 2012*Ownership interaction effect, no parameters across all 10 measures of HIT were significantly negative. Furthermore, the effect of hospital/system/HMO ownership actually strengthened over time for the overall index (9.3 percentage points, CI: 1.9,16.7), the electronic health record index (13.3, CI: 0.5,26.2), the registries index (12.7, CI: 0.8,24.7), and connecting the EHR to that of the main hospital (20.1, CI: 4.9,35.2) – all very large effects. This suggests that hospital/system/HMO-owned practices responded to the changing conditions regarding the adoption of HIT much more than independently-owned organizations, for both internally oriented and at least one externally oriented functionalities. In contrast, ownership was associated with later adoption of none of the measures of HIT functionalities at baseline. To restate, these results suggest that ownership was a key capability for the later adoption of electronic health record and registry functionalities, but this capability did not become salient until external pressures to adopt HIT had increased.

Additionally, no support was found for hypothesis **H2a**, that the effect of being affiliated with an IPA/PHO would diminish over time. While IPA/PHO affiliation was associated at baseline with an increase in the registries index (8.1, CI: 1.6,14.5) and with connecting the EHR to that of the main hospital (7.5, CI: 0.4,14.6), no evidence was found suggesting that the magnitudes of these associations changed over time.

Table 11: Effect of organizational ties on the change in adoption of HIT from 2008-2012, small and medium-sized physician practices, results from linear regression with organizational fixed effects

	Ownership: Hospital/ system/HMO (ref: phys.)	Received patients from an IPA/PHO	Year 2012* Ownership: Hospital/ system/HMO (ref: phys.)	Year 2012* Received patients from an IPA/PHO	Adj r-sq.
Overall HIT index	-7.885 [-16.394,0.623]+	2.398 [-1.853,6.649]	9.322 [1.929,16.715]*	2.812 [-2.608,8.232]	0.467
Internally oriented HIT index	-10.749 [-22.112,0.614]+	1.848 [-3.859,7.554]	12.903 [2.935,22.872]*	6.316 [-0.890,13.523]+	0.432
Electronic health record index	-10.544 [-25.348,4.260]	-1.332 [-8.677,6.012]	13.328 [0.494,26.162]*	5.628 [-3.930,15.185]	0.436
Registries index	-10.150 [-23.279,2.978]	8.062 [1.586,14.537]*	12.752 [0.766,24.739]*	7.339 [-1.648,16.326]	0.176
Externally oriented HIT index	-3.458 [-10.818,3.903]	3.200 [-0.786,7.186]	3.676 [-2.631,9.983]	-2.799 [-8.057,2.460]	0.265
Interoperability index	-3.540 [-14.222,7.143]	2.462 [-3.996,8.920]	1.101 [-7.694,9.897]	-3.198 [-11.420,5.023]	0.026
Electronic prescribing	-8.263 [-25.213,8.688]	0.584 [-8.396,9.563]	4.744 [-10.856,20.345]	5.847 [-5.597,17.291]	0.479
EHR connects to EHR at main hospital	-4.469 [-20.718,11.780]	7.484 [0.414,14.554]*	20.057 [4.887,35.226]**	-6.395 [-16.416,3.625]	0.091
Email	0.524 [-12.757,13.805]	4.438 [-2.340,11.217]	0.022 [-12.336,12.380]	-4.408 [-13.628,4.812]	0.065
Access EHR online	-1.377 [-14.578,11.824]	2.509 [-4.939,9.956]	-2.395 [-13.786,8.996]	-5.038 [-14.775,4.699]	0.212

Notes: +p<0.10; *p<0.05; **p<0.01. N=1440. This table shows results from ten separate regressions; each row represents one model, for which the dependent variable is listed on the left column of this table. All variables shown in descriptive statistics were also included in each model presented above. Standard errors were clustered by physician organization to account for non-independence between the same organization over time. Abbreviations: EHR electronic health record; HMO, health maintenance organization; HIT, health information technology; IPA, independent practice association; PHO, physician-hospital organization. Data source: The cohort of physician practices responding to both the National Study of Small and Medium-sized Physician Practices (July 2007 - March 2009) and the National Study of Physician Organizations III (January 2012 – ongoing; data from responses up to March 2013).

4A.5. Association between HIT and incentives

Early adoption

Hypothesis **H3**, where direct incentives, as measured by the opportunity to receive bonus income for the adoption or use of HIT, were hypothesized to be associated with the adoption of HIT was strongly supported. Direct incentives, as measured by the opportunity to receive bonus income for the adoption or use of HIT, were associated with a large and significant increase in the overall HIT index early on (9.3, CI: 6.3,12.4) (**Table 12**). Additionally, especially strong associations were found between direct incentives and the electronic health record index (14.6, CI: 7.7,21.6) and electronic prescribing (20.0, 10.0,30.0). In light of rates of adoption hovering around 30 percentage points for most functionalities at this time, these extremely large effects suggest that most adopters reported the opportunity to receive bonus income for the adoption or use of HIT. However, one key limitation of this measure is that it is possible that non-adopting practices were simply not aware of the opportunity to receive such bonuses even when they were available, potentially leading to under-reporting on the survey instrument.

Hypothesis **H4** posited that indirect incentives – as measured by public reporting of data on quality and/or efficiency and the opportunity to receive bonus income for quality and/or efficiency – would also be associated with the early adoption of HIT. However, only one of the two indicators – public reporting – was significantly associated with the overall HIT index (2.4, CI: 1.1,3.7) and several other measures of HIT, including both the internally oriented (3.1, CI 1.0,5.2) and externally oriented (1.5, CI: 0.1,2.8) indices. Surprisingly, the opportunity to receive bonus income for quality/efficiency of care was not associated with the adoption of HIT. While the associations between public reporting and the adoption of HIT were moderate in size, they do suggest that practices choosing to publically report their data were somewhat more likely than others to adopt HIT. However, the potential for reverse causation is an important limitation for this finding. Thus, only partial support was found for the hypothesis that indirect incentives would also help drive the adoption of HIT.

Later adoption

As with hypotheses **H1b** and **H2a**, no evidence was found for hypotheses **H3a** and **H4a**, that the effects of either direct incentives or indirect incentives diminished over time (**Table 13**). In fact, the association between the opportunity to receive bonus income for quality or efficiency – one of the measures of indirect incentives – even strengthened over time for the overall HIT index (4.4, CI: 1.1,7.7).

Table 12: Effect of direct and indirect incentives on the adoption of HIT by 2008, small and medium-sized physician practices, results from cross-sectional linear regression

	Bonus income for IT	Public reporting index (0-2)	Bonus income for quality/efficiency (0-2)	Adj r-sq.
Overall HIT index	9.408 [5.140,13.675]**	2.436 [1.137,3.735]**	-0.250 [-1.703,1.204]	0.174
Internally oriented HIT index	11.799 [6.448,17.149]**	3.090 [0.993,5.188]**	-0.654 [-2.230,0.922]	0.170
Electronic health record index	14.631 [7.705,21.557]**	2.081 [-0.686,4.849]	-2.492 [-5.016,0.033]+	0.128
Registries index	6.724 [1.088,12.360]*	4.821 [2.827,6.815]**	2.594 [-0.900,6.088]	0.163
Externally oriented HIT index	5.606 [1.722,9.490]**	1.467 [0.136,2.798]*	0.404 [-1.928,2.736]	0.120
Interoperability index	2.993 [-2.225,8.211]	2.116 [0.174,4.057]*	1.442 [-1.365,4.250]	0.114
Electronic prescribing	19.981 [9.973,29.989]**	0.159 [-2.656,2.974]	2.341 [-3.610,8.293]	0.077
EHR connects to EHR at main hospital	6.238 [-0.401,12.877]+	2.178 [0.561,3.795]*	-2.449 [-5.386,0.489]+	0.112
Email	3.898 [-1.167,8.963]	0.655 [-2.212,3.522]	-0.724 [-4.033,2.585]	0.075
Access EHR online	0.147 [-2.109,2.404]	0.931 [0.197,1.666]*	-0.669 [-1.899,0.561]	0.028

Notes: +p<0.10; *p<0.05; **p<0.01. N=1736. This table shows results from ten separate regressions; each row represents one model, for which the dependent variable is listed on the left column of this table. All variables shown in descriptive statistics were also included in each model presented above. Standard errors were adjusted to reflect the complex sampling frame of the National Survey of Small and Medium Sized Physician Practices. Abbreviations: HIT, health information technology; EHR electronic health record. Data source: National Study of Small and Medium-sized Physician Practices (July 2007 - March 2009).

Table 13: Effect of direct and indirect incentives on the change in adoption of HIT from 2008-2012, small and medium-sized physician practices, results from linear regression with organiztional fixed effects

				Year 2012*	Year 2012*	Year 2012*	
	Bonus income for IT	Public reporting index (0-2)	Bonus income for quality/efficiency (0-2)	Bonus income for IT	Public reporting index (0-2)	Bonus income for quality/efficiency (0-2)	Adj r-sq.
Overall HIT index	4.215 [-1.022,9.451]	1.961 [-0.303,4.226]+	-1.032 [-3.887,1.823]	-0.501 [-7.189,6.188]	-1.610 [-4.564,1.343]	4.383 [1.094,7.671]**	0.467
Internally oriented HIT index	4.420 [-2.681,11.521]	2.007 [-1.033,5.047]	-0.904 [-4.794,2.986]	1.672 [-7.302,10.645]	-2.077 [-6.026,1.873]	5.991 [1.675,10.306]**	0.432
Electronic health record index	6.050 [-2.764,14.864]	0.631 [-3.179,4.441]	-2.584 [-7.493,2.325]	-4.124 [-15.555,7.308]	-1.573 [-6.438,3.291]	6.369 [0.500,12.239]*	0.436
Registries index	2.194 [-7.167,11.556]	4.239 [0.457,8.022]*	2.402 [-2.289,7.094]	10.936 [-0.371,22.243]+	-2.605 [-7.460,2.251]	5.202 [-0.022,10.425]+	0.176
Externally oriented HIT index	3.740 [-1.133,8.614]	1.919 [-0.249,4.087]+	-1.232 [-4.054,1.591]	-3.844 [-10.056,2.368]	-0.919 [-3.634,1.796]	1.835 [-1.319,4.989]	0.265
Interoperability index	2.984 [-4.731,10.699]	2.209 [-1.437,5.854]	-3.167 [-7.923,1.590]	-4.368 [-14.348,5.611]	-1.396 [-5.637,2.844]	1.012 [-4.336,6.361]	0.026
Electronic prescribing	17.603 [6.930,28.275]**	-0.520 [-5.225,4.185]	2.737 [-3.196,8.670]	-18.924 [-32.201,-5.647]**	3.188 [-2.839,9.214]	2.644 [-4.194,9.481]	0.479
EHR connects to EHR at main hospital	9.259 [-0.313,18.830]+	4.788 [1.129,8.446]*	-2.299 [-7.049,2.451]	-5.446 [-17.062,6.170]	-3.016 [-8.096,2.064]	2.316 [-3.135,7.768]	0.091
Email	-1.703 [-11.235,7.829]	1.046 [-2.993,5.084]	-1.444 [-6.809,3.922]	0.840 [-10.902,12.583]	-0.854 [-6.124,4.416]	4.391 [-1.251,10.032]	0.065
Access EHR online	-7.927 [-17.245,1.391]+	1.493 [-2.508,5.495]	1.882 [-2.947,6.711]	9.724 [-1.372,20.820]+	-1.564 [-6.575,3.447]	0.458 [-5.218,6.134]	0.212

Notes: +p<0.10; *p<0.05; **p<0.01. N=1440. This table shows results from ten separate regressions; each row represents one model, for which the dependent variable is listed on the left column of this table. All variables shown in descriptive statistics were also included in each model presented above. Standard errors were clustered by physician organization to account for non-independence between the same organization over time. Abbreviations: HIT, health information technology; EHR electronic health record. Data source: The cohort of physician practices responding to both the National Study of Small and Medium-sized Physician Practices (July 2007 - March 2009) and the National Study of Physician Organizations III (January 2012 – ongoing; data from responses up to March 2013).

4A.6. Other findings of interest

In addition to the organizational ties and incentives discussed above, as expected ,practice size was also very strongly and positively associated with the early adoption of nine of ten measures of HIT (**Appendix D: Tables D1a,b,c**). Because practice size was logged in analyses, to account for diminishing returns from increased practice size, the coefficient on practice size is interpreted as the effect of practice size on the adoption of HIT for a 100 percent increase in practice size (Wooldridge 2006: p. 49). For the overall HIT index, a 100 percent increase in practice size (so, for example, comparing a two physician practice to a four physician practice) was associated with a 5.1 percentage point increase (CI: 3.6,6.6). Notably, practice size was especially strongly associated with the EHR index (9.4, CI: 6.7,12.1) and electronic prescribing (6.9, CI: 3.7,10.1).

Looking at later adoption, by 2012 (**Appendix D: Tables D2a,b,c**), practice size was not associated with an increase in any of the measures of HIT at baseline, but the effect of practice size grew in magnitude over time, as the conditions around the adoption of HIT shifted, for six of ten measures of HIT, including for the EHR index (4.7, CI: 0.8,8.7). This suggests that smaller physician practices were less likely than larger practices to be early or somewhat later adopters of HIT.

Additionally, three measures capturing the quality orientation of practices were of interest: the patient-centered management index (range: 0-5), whether practices participated in a quality improvement (QI) program, and whether they reported using plan-do-study-act (PDSA) methods of rapid-cycle quality improvement. All three were strongly associated with the overall HIT index in 2008 (patient-centered management index 0.8, CI: 0.3,1.4; QI program 4.4, CI: 1.4,7.5; PDSA 8.3, CI: 4.7,11.9), and were especially strongly associated with the registries index.

With respect to later adoption, the association between the patient-centered management index and the overall HIT index increased in magnitude over time (1.5, CI: 0.2,2.9), as did the association for participating in a QI program (8.2, CI: 1.0,15.3). However, curiously, the association between use of PDSA methods and the overall HIT index significantly diminished (-9.4, CI: -17.5,-1.3).

4A.7. Summary of support for hypotheses

Out of the nine hypotheses developed, at least some support was provided for five of the hypotheses for the cohort of small/medium-sized physician practices. **Table 14** summarizes the extent that support was found for each hypothesis.

Table 14: Support for hypotheses: Small/medium-sized physician practices

H1	Physician organizations owned by hospitals, health systems, or HMOs will be more likely than independently owned organizations to adopt HIT early on than other organizations.
	Strong support. Ownership was moderately associated with overall HIT index early on and was strongly associated with the externally oriented HIT index, interoperability index, and connecting the EHR to that of the main hospital.
H1a	Physician organizations owned by hospitals, health systems, or HMOs will be more likely than independently owned organizations to adopt externally oriented HIT early on, especially to the extent that functionalities improve communication with those external entities.
	Strong support. Ownership was much more strongly associated with the externally oriented index than with the internally oriented index in the first period.
H1b	As adoption of a given measure of HIT increases over time, due to increased imitation pressures, the association between ownership and the adoption of HIT will diminish.
	No support. The association between ownership and five out of ten measures of HIT actually strengthened over time with respect to later adoption, contra as hypothesized.
H2	Physician organizations affiliated with an independent practice association or a physician-hospital organization will be more likely than others to adopt HIT early on.
	Mixed support. Affiliation with an IPA/PHO was moderately associated with the registries index, the interoperability index and with connecting the EHR to that of the main hospital, but was not associated with other measures.
H2a	As adoption of a given measure of HIT increases over time, due to increased imitation pressures, the association between affiliation with an IPA/PHO and the adoption of HIT will diminish.
	No support. The association between affiliation with an IPA/PHO and the later adoption of HIT neither diminished nor strengthened over time.
H3	Organizations reporting the opportunity to receive bonus income from the adoption or use of HIT early on may be more likely to have adopted HIT early on than other organizations.
	Strong support. The opportunity to receive bonus income for the adoption or use of HIT was strongly associated with the early adoption of six of ten measures of HIT, including both the internally oriented and externally oriented indices.
H3a	As the Meaningful Use program is implemented, the association between direct incentives and the adoption of HIT will diminish.
	No support. The association between the opportunity to receive bonus income for the adoption or use of HIT and the later adoption of HIT neither diminished nor strengthened over time.
H4	Organizations exposed to incentives for outcomes other than the adoption of HIT but for which HIT may indirectly make easier to achieve may be more likely to have adopted HIT early on.
	Mixed support. Publicly reporting of data was moderately associated with the early adoption of seven of ten measures of HIT, including both the internally oriented and externally oriented indices. However, opportunity to receive bonus income for quality/efficiency was not associated with any measures of HIT.
H4a	As the Meaningful Use program is implemented, the association between indirect incentives and the adoption of HIT will diminish.
	No support. The association between both measures of indirect incentives and the later adoption of HIT neither diminished nor strengthened over time.

4B. RESULTS: LARGE MEDICAL GROUPS

4B.1. Summary of the chapter

This sub-chapter discusses results for the sample of large medical groups. In the first two sections, summary statistics are discussed, followed by three sections discussing multivariate results. A final section summarizes the extent to which support for hypotheses was found.

4B.2. Patterns in the adoption of health information technology

Adoption rates of functionalities

Large medical groups (having 20 or more physicians in the first round) demonstrated trends similar to the smaller practices. Among the 101 large medical groups responding to both survey rounds (first round: 3/2006-3/2007; second round: 1/2012- ongoing, with data extracted 3/2013), rates increased significantly for all functionalities except registries for depression, connecting to the EHR of the group's main hospital, and using email with patients (**Table 4b**). As with the smaller physician practices, connecting to the EHR of the group's main hospital and using email with patients remained well under 50%, even in the second period. However, in both periods, the large medical groups generally showed substantially higher rates of adoption for most functionalities in comparison to the small/medium-sized practices.

When comparing the large medical groups responding to both the 2006 and 2012 surveys with those responding to only one survey round, few differences emerged in trends in the adoption of HIT functionalities (**Table 5b**). However, respondents of both surveys were somewhat more likely to have adopted three of for chronic disease registries and electronic laboratory results in 2012.

Indices of health information technology functionalities

The overall HIT index increased from an average of 43 percent of functionalities adopted in 2006 to 69 percent adopted in 2012 – an increase of 26 percentage points (**Table 6b**). Relative to the small/medium-sized practices, larger groups adopted more HIT in both periods, but the rate at which adoption increased was similar. For large medical groups, the highest sub-index in 2012 and the sub-index showing the greatest increase over time was the electronic health record index; in 2012, on average, large medical groups had adopted 87 percent of the functionalities included in the EHR index.

In general, large medical groups responding to both rounds of the survey differed little from those responding to only one round (**Table 7b**). Two minor exceptions were that one-time respondents in 2012 reported adopting registries somewhat less frequently than medical groups responding to both survey rounds (26 percent vs. 42 percent, p=0.005), and one time-respondents reported adopting functionalities in the interoperability index somewhat more frequently (94 percent vs. 73 percent, p=0.052.

Table 4b: Adoption of HIT functionalities by medical groups responding to both surveys, 2006 and 2012

	National survey of physician organizations II (2006) , % n=(101)	National survey of physician organizations III (2012) , % n=(101)	P-value	Difference, mean %
Ambulatory care progress notes	52.5	90.1	**0.000**	37.6
List of patient medications	50.5	94.1	**0.000**	43.6
Problem list	49.5	92.1	**0.000**	42.6
Alerts for potential drug interactions	45.5	93.1	**0.000**	47.5
Alerts for abnormal test results	41.6	77.2	**0.000**	35.6
Prompts at time of patient visit	40.6	75.2	**0.000**	34.7
EHR used to measure quality	43.6	89.1	**0.000**	45.5
Registry: Diabetes	47.5	62.4	**0.011**	14.9
Registry: Asthma	27.7	38.6	**0.048**	10.9
Registry: Congestive heart failure	34.7	48.5	**0.008**	13.9
Registry: Depression	20.8	18.8	0.672	-2.0
Physician electronic prescribing	43.6	93.1	**0.000**	49.5
Laboratory test results	75.2	95.0	**0.000**	19.8
Emergency department notes	53.5	81.2	**0.000**	27.7
Hospital discharge summaries	63.4	86.1	**0.000**	22.8
EHR connects to EHR at main hospital	35.6	34.7	0.854	-1.0
Physicians use e-mail with patients	33.7	23.8	0.068	-9.9
Patients can access part of EHR online	9.9	47.5	**0.000**	37.6

Note: The p-values were derived from t-tests comparing levels of adoption in the first and second survey periods. Abbreviations: EHR electronic health record; HIT, health information technology.

Table 5b: Adoption of HIT functionalities by medical groups, 2006 and 2012

	National survey of physician organizations II				National survey of physician organizations III			
	Overall n=(321)	Responded in one round n=(220)	Responded in both rounds n=(101)	p-value	Overall n=(159)	Responded in one round n=(58)	Responded in both rounds n=(101)	p-value
Ambulatory care progress notes	51.7	51.4	52.5	0.854	91.2	93.1	90.1	0.505
List of patient medications	52.0	52.7	50.5	0.712	93.7	93.1	94.1	0.816
Problem list	50.2	50.5	49.5	0.875	92.5	93.1	92.1	0.812
Alerts for potential drug interactions	43.3	42.3	45.5	0.586	92.5	91.4	93.1	0.708
Alerts for abnormal test results	40.2	39.5	41.6	0.731	78.0	79.3	77.2	0.760
Prompts at time of patient visit	37.1	35.5	40.6	0.383	73.6	70.7	75.2	0.540
EHR used to measure quality	46.1	47.3	43.6	0.537	89.3	89.7	89.1	0.915
Registry: Diabetes	50.8	52.3	47.5	0.431	54.7	41.4	62.4	**0.011**
Registry: Asthma	31.5	33.2	27.7	0.321	32.1	20.7	38.6	**0.014**
Registry: Congestive heart failure	36.8	37.7	34.7	0.595	42.1	31.0	48.5	**0.028**
Registry: Depression	23.1	24.1	20.8	0.508	16.4	12.1	18.8	0.249
Physician electronic prescribing	42.4	41.8	43.6	0.770	93.1	93.1	93.1	0.994
Laboratory test results	74.8	74.5	75.2	0.893	96.9	100.0	95.0	**0.024**
Emergency department notes	49.8	48.2	53.5	0.381	84.3	89.7	81.2	0.134
Hospital discharge summaries	62.3	61.8	63.4	0.791	88.7	93.1	86.1	0.150
EHR connects to EHR at main hospital	31.8	30.0	35.6	0.323	35.8	37.9	34.7	0.682
Physicians use e-mail with patients	35.2	35.9	33.7	0.695	20.1	13.8	23.8	0.112
Patients can access part of EHR online	8.4	7.7	9.9	0.534	42.8	34.5	47.5	0.107

The p-values for each year signify whether practices responding to both round of the survey differed significantly from those responding to only one round. Abbreviations: EHR electronic health record; HIT, health information technology.

Table 6b: Adoption of HIT indices by medical groups, 2006 and 2012

	National survey of physician organizations II (2006) n=(101)	National survey of physician organizations III (2012) n=(101)	P-value	Difference, mean
Overall HIT index	43.2	68.9	**0.000**	25.8
Internally oriented HIT index	42.1	70.8	**0.000**	28.8
Electronic health record index	46.3	87.3	**0.000**	41.0
Registries index	34.3	42.1	0.062	7.8
Externally oriented HIT index	45.0	65.9	**0.000**	20.9
Interoperability index	64.0	87.5	**0.000**	23.4

Note: The p-values were derived from t-tests comparing levels of adoption in the first and second survey periods. Abbreviations: health information technology.

Table 7b: HIT indices for medical groups, 2006 and 2012

	National survey of physician organizations II (2006)				National survey of physician organizations III (2012)			
	Cronbach's alpha n=(321)	Responded in one round n=(220)	Responded in both rounds n=(101)	p-value	Cronbach's alpha n=(159)	Responded in one round n=(58)	Responded in both rounds n=(101)	p-value
Overall HIT index	0.911	43.0	43.2	0.976	0.773	65.4	68.9	0.216
Internally oriented HIT index	0.900	43.1	42.1	0.806	0.724	65.0	70.8	0.089
Electronic health record index	0.946	45.6	46.3	0.900	0.893	87.2	87.3	0.985
Registries index	0.869	38.9	34.3	0.353	0.775	26.3	42.1	**0.005**
Externally oriented HIT index	0.777	42.9	45.0	0.561	0.615	66.0	65.9	0.975
Interoperability index	0.833	61.5	64.0	0.611	0.738	94.3	87.5	0.052

Note: The p-values for each year signify whether practices responding to both round of the survey differed significantly from those responding to only one round. Abbreviations: health information technology.

4B.3. Organizational characteristics and external factors over time

Organizational characteristics and external factors

With respect to the large medical groups, the average size of responding organizations in 2006 was very large – just less than 200 physicians; however, the median respondent was much closer to 60 physicians, suggesting few very large organizations drove up the average practice size (**Table 8b**). Additionally, the majority – 70 to 80 percent – were multi-specialty or specialty practices. The large medical groups reported receiving around 50 percent of their revenue from commercial health plans. Around 10 percent of medical groups were located in non-metropolitan area.

Relatively minimal differences were found between organizations responding to only one round of the survey and organizations responding to both survey rounds. In 2006, one-time responders were more likely to be multi-specialty practices, while they were less likely to be multi-specialty or specialty practices in 2012. One time responders in 2012 also had lower values on the health plan index, on average, and also reported fewer opportunities to receive bonus income for the quality and efficiency of the care they provided.

Characteristics of early, late and non-adopters

For the panel of large medical groups, fewer differences were observed between medical groups adopting any EHR functionalities by 2006 (“early adopters,” n=58), those adopting any EHR functionalities by 2012 (“majority adopters,” n=38), and medical groups not yet adopting any functionalities by 2012 (“non-adopters,” n=5) (**Table 9b**). Still, non-adopting medical groups were substantially smaller, on average, than majority adopters (majority: 70 physicians, non-adopting: 27 physicians). Substantial differences remained even when comparing the median practice size of the groups.

Table 8b: Organizational characteristics and external factors for medical groups, over time, in and out of the panel

	National survey of physician organizations II (2006)			National survey of physician organizations III (2012)		
	Responded in one round n=(220)	Responded in both rounds n=(101)	p-value	Responded in one round n=(58)	Responded in both rounds n=(101)	p-value
Practice size, mean	185.0	185.4	0.995	80.2	214.9	0.071
Practice size, median	68.0	58.0		40.0	61.0	
Specialty mix, %						
Primary care	26.8	30.7	0.482	39.7	35.6	0.619
Multispecialty	11.4	4.0	**0.011**	34.5	60.4	**0.001**
Specialty	61.8	65.3	0.542	25.9	4.0	**0.000**
Patient-centered management index (0-5), mean	1.1	1.3	0.273	1.3	1.5	0.375
Participated in QI program, %	30.0	33.7	0.517	50.0	55.4	0.512
Revenue,mean %						
Medicare	30.0	27.3	0.167	31.1	28.7	0.366
Medicaid	12.2	12.7	0.815	15.0	12.7	0.342
Uninsured	6.4	6.7	0.773	7.6	8.5	0.606
Commercial	46.3	48.8	0.379	39.0	44.7	0.097
Other	5.1	4.5	0.609	7.4	5.4	0.396
Ownership, %						
Physician owned	51.8	55.4	0.546	32.8	43.6	0.176
Hospital/system/HMO owned	32.7	30.7	0.717	53.4	43.6	0.233
Other	15.5	13.9	0.707	13.8	11.9	0.733
Received patients from an IPA/PHO, %	51.8	48.5	0.584	17.2	14.9	0.698
Bonus income for quality/efficeincy (0-2), mean	0.78	0.77	0.958	0.83	1.17	**0.008**
Bonus income for IT, %	23.2	32.7	0.085	27.6	19.8	0.277
HMO penetration rate, mean	27.1	26.6	0.765	22.9	24.7	0.323
Population density, %						
Metropolitan area	92.3	88.1	0.263	89.7	88.1	0.767
Non-metropolitan area	7.7	11.9	0.263	10.3	11.9	0.767

Note: The p-values for each year signify whether practices responding to both round of the survey differed significantly from those responding to only one round. Abbreviations: HMO, health maintenance organization; HIT, health information technology; IPA, independent practice association; PHO, physician-hospital organization; QI, quality improvement.

Table 9b: profiles of medical groups adopting HIT earlier, later, and non-adopters

	Adopted EHR by 2006 n=(58)	Adopted EHR by 2012 n=(38)	Had not adopted EHR by 2012 n=(5)
Practice size, mean	274.2	70.5	27.0*
Practice size, median	82.5	46.0	27.0
Specialty mix, %			
Primary care	25.9	36.8	40.0
Multispecialty	6.9*	0.0	0.0*
Specialty	67.2	63.2	60.0
Patient-centered management index (0-5), mean	1.4	1.4	0.2*
Participated in QI program, %	36.2	26.3	60.0
Revenue, mean %			
Medicare	30.9*	23.9	12.2*
Medicaid	7.7*	17.2	36.4
Uninsured	5.0*	9.3	5.8
Commercial	52.1	45.2	37.4
Other	4.4	4.3	8.2
Ownership, %			
Physician owned	60.3	50.0	40.0
Hospital/system/HMO owned	32.8	26.3	40.0
Other	6.9*	23.7	20.0
Health plan index (0-5), mean	2.8	2.6	1.8
Received patients from an IPA/PHO, %	44.8	50.0	80.0
Bonus income for quality/efficiency (0-2), mean	0.8	0.7	1.0
Bonus income for IT, %	39.7	23.7	20.0
Physicians per 1000 persons, mean	3.5	3.2	3.7
Number of hospitals, mean	16.8	18.2	10.4
HMO penetration rate, mean	24.9	29.2	26.5
Population density, %			
Metropolitan area	89.7	86.8	80.0
Non-metropolitan area	10.3	13.2	20.0

Notes: N=101. Data are baseline data, collected in 2006. The t-tests compare majority-adopters to early-adopters and non-adopters. *p<.05. Abbreviations: EHR electronic health record; HIT, health information technology; HMO, health maintenance organization; IPA, independent practice association; PHO, physician-hospital organization; QI, quality improvement.

4B.4. Association between HIT and organizational ties

Early adoption

Hypotheses for the large medical group mirrored those for the small and medium-sized physician practices. Hypothesis **H1** posited that Hospital/health system/HMO ownership would be associated with the adoption of HIT in 2006. However, no support for this hypothesis was found (**Table 15**).

Table 15: Effect of organizational ties on the adoption of HIT by 2008, small and medium-sized physician practices, results from cross-sectional linear regression

	Ownership: Hospital/ system/HMO (ref: phys.)	Received patients from an IPA/PHO	Adj r-sq.
Overall HIT index	0.090 [-8.127,8.306]	2.640 [-3.793,9.074]	0.206
Internally oriented HIT index	0.232 [-9.545,10.008]	2.876 [-5.078,10.831]	0.163
Electronic health record index	-1.230 [-13.357,10.898]	1.249 [-8.218,10.716]	0.147
Registries index	5.419 [-6.149,16.987]	3.558 [-5.919,13.034]	0.118
Externally oriented HIT index	-0.052 [-8.257,8.153]	1.988 [-4.392,8.369]	0.182
Interoperability index	-2.931 [-14.481,8.618]	0.372 [-8.951,9.696]	0.084
Electronic prescribing	-3.610 [-17.242,10.022]	4.738 [-6.888,16.363]	0.048
EHR connects to EHR at main hospital	4.484 [-9.645,18.614]	-0.415 [-11.000,10.170]	0.148
Email	3.862 [-10.592,18.315]	4.199 [-7.379,15.777]	0.073
Access EHR online	3.696 [-4.967,12.359]	4.277 [-1.932,10.485]	0.106

Notes: +p<0.10; *p<0.05; **p<0.01. N=321. This table shows results from ten separate regressions; each row represents one model, for which the dependent variable is listed on the left column of this table. All variables shown in descriptive statistics were also included in each model presented above. Robust standard errors were used to account for heterogeneity. Abbreviations: EHR electronic health record; HMO, health maintenance organization; HIT, health information technology; IPA, independent practice association; PHO, physician-hospital organization. Data source: National Study of Physician Organizations II (March 2006 - March 2007).

Likewise, **H2** suggested that practices affiliated with an IPA or PHO would be more likely to have adopted HIT, but no evidence was found suggesting that IPA/PHO affiliated medical groups were more likely to have adopted HIT by 2006. These results suggest that organizational ties, as measured by ownership and affiliation with an IPA/PHO were much less relevant for large medical groups in making the decision to become early adopters of HIT, in comparison to the small/medium-sized physician practices.

Later adoption

A lack of support was also found for hypotheses **H1a** and **H2a**, that, respectively, the effect of ownership and affiliation with an IPA/PHO would diminish over time (**Table 16**).Simply, organizational ties appear not to have mattered much for the cohort of large medical groups, at least with respect to the adoption of HIT.

Table 16. Effect of organizational ties on the change in adoption of HIT from 2006-2012, large medical groups, results from linear regression with organiztional fixed effects

			Year 2012*	Year 2012*	
	Ownership: Hospital/ system/HMO (ref: phys.)	Received patients from an IPA/PHO	Ownership: Hospital/ system/HMO (ref: phys.)	Received patients from an IPA/PHO	Adj r-sq.
Overall HIT index	-7.978 [-26.365,10.408]	7.186 [-6.480,20.852]	15.123 [-2.649,32.895]+	-3.825 [-25.277,17.628]	0.563
Internally oriented HIT index	-18.715 [-40.792,3.362]+	12.480 [-6.426,31.386]	22.124 [-0.819,45.067]+	-11.696 [-39.994,16.601]	0.525
Electronic health record index	-30.928 [-61.006,-0.849]*	10.769 [-12.456,33.994]	24.547 [-3.434,52.528]+	-14.690 [-48.772,19.392]	0.550
Registries index	5.562 [-20.371,31.495]	14.221 [-4.934,33.377]	16.502 [-9.660,42.663]	-7.555 [-41.484,26.374]	0.271
Externally oriented HIT index	8.573 [-10.636,27.782]	-1.146 [-14.910,12.617]	4.448 [-14.541,23.437]	8.071 [-12.828,28.970]	0.398
Interoperability index	25.599 [-5.205,56.403]	-9.502 [-30.120,11.116]	6.044 [-23.619,35.707]	21.817 [-8.435,52.068]	0.353
Electronic prescribing	-11.273 [-41.788,19.242]	1.753 [-23.233,26.738]	14.246 [-15.963,44.455]	-9.624 [-45.998,26.750]	0.626
EHR connects to EHR at main hospital	-33.994 [-69.300,1.312]+	-0.337 [-25.294,24.620]	19.197 [-13.275,51.668]	3.092 [-30.174,36.358]	0.240
Email	26.349 [-15.590,68.288]	6.203 [-20.907,33.313]	-16.530 [-57.017,23.957]	2.944 [-40.547,46.435]	0.107
Access EHR online	2.130 [-33.978,38.238]	12.866 [-9.348,35.079]	-3.909 [-35.463,27.645]	-5.365 [-40.682,29.953]	0.456

Notes: +p<0.10; *p<0.05; **p<0.01. N=202. This table shows results from ten separate regressions; each row represents one model, for which the dependent variable is listed on the left column of this table. All variables shown in descriptive statistics were also included in each model presented above. Standard errors were clustered by physician organization to account for non-independence between the same organization over time. Abbreviations: EHR electronic health record; HMO, health maintenance organization; HIT, health information technology; IPA, independent practice association; PHO, physician-hospital organization. Data source: The cohort of medical groups responding to both the National Study of Physician Organizations II (March 2006 - March 2007) and the National Study of Physician Organizations III (January 2012 – ongoing; data from responses up to March 2013).

4B.5. Association between HIT and incentives

Early adoption

In contrast to the effects of organizational ties, direct financial incentives for the adoption or use of HIT were strongly associated with the early adoption of HIT, as hypothesized by hypothesis **H3** (**Table 17**). Further, direct incentives, as measured by the opportunity to receive bonus income for the adoption or use of HIT, were associated with both the internally oriented HIT index (14.7, CI: 5.0,24.4) and the externally oriented HIT index (10.6, CI: 1.5,19.7). Notably, these results are consistent with prior research using this dataset (Robinson et al. 2009).

Table 17: Effect of direct and indirect incentives on the adoption of HIT by 2006, large medical groups, results from cross-sectional linear regression

	Bonus income for IT	Bonus income for quality/efficiency (0-2)	Adj r-sq.
Overall HIT index	13.088 [4.707,21.469]**	-0.444 [-4.822,3.935]	0.206
Internally oriented HIT index	14.664 [4.943,24.385]**	1.092 [-4.160,6.344]	0.163
Electronic health record index	15.403 [2.954,27.852]*	-2.695 [-9.227,3.836]	0.147
Registries index	11.476 [-1.077,24.029]+	8.003 [1.715,14.291]*	0.118
Externally oriented HIT index	10.573 [1.465,19.681]*	-2.675 [-7.164,1.814]	0.182
Interoperability index	13.539 [1.288,25.789]*	-3.870 [-10.498,2.758]	0.084
Electronic prescribing	5.669 [-10.597,21.936]	-1.926 [-9.947,6.095]	0.048
EHR connects to EHR at main hospital	15.240 [1.248,29.231]*	-5.398 [-12.367,1.572]	0.148
Email	4.365 [-11.072,19.803]	0.853 [-6.988,8.695]	0.073
Access EHR online	8.118 [-1.625,17.862]	-0.645 [-4.916,3.626]	0.106

Notes: +p<0.10; *p<0.05; **p<0.01. N=321. This table shows results from ten separate regressions; each row represents one model, for which the dependent variable is listed on the left column of this table. All variables shown in descriptive statistics were also included in each model presented above. Robust standard errors were used to account for heterogeneity. Abbreviations: HIT, health information technology; EHR electronic health record. Data source: National Study of Physician Organizations II (March 2006 - March 2007).

Additionally, curiously, unlike with the organizations in the small/medium-sized cohort, direct incentives were not associated with the adoption of electronic prescribing for the large medical groups. It is possible that the difference in when the surveys were fielded (largely 2006 vs. 2008) was meant that different kinds of incentives were available.

Indirect incentives, which were only measured through the opportunity to receive bonus income for quality or efficiency of care, were not associated with the overall HIT index, as hypothesized by **H4**. Indirect were only associated with the early adoption of registries (8.0, CI: 1.7,14.3), a fairly large effect given that the mean level of the registries index was 34 percentage points in the first period.

Later adoption

Regarding hypotheses **H3a** – that the effect of direct incentives would wane over time – and **H4a** – that the effect of indirect incentives would wane over time – no evidence was found

for either hypothesis (**Table 18**). It is likely that the effects of both incentives were washed out by the Meaningful Use program, under which the great majority of large medical groups would have adopted robust HIT systems even without additional incentives.

4B.6. Other findings of interest

As with the small and medium-sized practices, organizational size was also strongly associated with all ten of the measures of HIT in 2006 for the large medical groups (**Appendix D: Tables D3a,b,c**).. A 100 percent increase in practice size was associated with an 8.8 percentage point increase in the overall HIT index (CI: 5.7,12.0), a very strong effect.

However, for later adoption, organizational size was not associated with the adoption of HIT at baseline, nor did the effect shift over time (**Appendix D: Tables D4a,b,c**). This suggests that, by 2012, the larger medical groups tended to adopt HIT regardless of their size. The null effect for organizational size on later adoption may also be due to "ceiling effects," stemming from the very high level of adoption (on average, medical groups had adopted nearly 70 percent of all measured HIT functionalities).

4B.7. Summary of support for hypotheses

Out of the nine hypotheses developed, at least some support was provided for only two of the hypotheses for the cohort of large medical groups. **Table 19** summarizes the extent that support was found for each hypothesis and sub-components.

Table 18. Effect of direct and indirect incentives on the change in adoption of HIT from 2006-2012, large medical groups, results from linear regression with organiztional fixed effects

			Year 2012*	Year 2012*	
	Bonus income for IT	Bonus income for quality/efficiency (0-2)	Bonus income for IT	Bonus income for quality/efficiency (0-2)	Adj r-sq.
Overall HIT index	16.933 [-4.918,38.784]	0.373 [-11.803,12.549]	-2.649 [-20.925,15.628]	0.339 [-8.868,9.546]	0.563
Internally oriented HIT index	19.200 [-6.909,45.310]	-0.313 [-15.010,14.385]	-4.040 [-27.733,19.652]	1.625 [-9.440,12.690]	0.525
Electronic health record index	17.780 [-17.787,53.347]	-2.842 [-22.725,17.041]	-3.486 [-33.912,26.940]	-2.585 [-17.317,12.146]	0.550
Registries index	22.001 [-12.474,56.477]	4.171 [-11.567,19.909]	-6.482 [-31.456,18.492]	10.088 [-2.447,22.624]	0.271
Externally oriented HIT index	13.505 [-13.874,40.885]	1.426 [-12.515,15.366]	-0.546 [-19.956,18.864]	-1.587 [-11.983,8.809]	0.398
Interoperability index	3.590 [-36.212,43.392]	7.400 [-16.889,31.689]	2.421 [-25.812,30.653]	-0.015 [-17.397,17.367]	0.353
Electronic prescribing	27.104 [-13.659,67.866]	0.956 [-24.141,26.052]	-1.739 [-32.487,29.009]	-10.769 [-27.893,6.355]	0.626
EHR connects to EHR at main hospital	30.295 [-17.714,78.305]	12.405 [-6.797,31.606]	-2.888 [-34.234,28.458]	-15.661 [-32.436,1.113]+	0.240
Email	7.429 [-45.891,60.749]	-7.720 [-42.383,26.942]	-5.829 [-41.141,29.483]	7.849 [-10.621,26.318]	0.107
Access EHR online	18.939 [-22.635,60.514]	-17.860 [-46.395,10.674]	-0.628 [-31.495,30.239]	7.517 [-10.457,25.491]	0.456

Notes: +p<0.10; *p<0.05; **p<0.01. N=202. This table shows results from ten separate regressions; each row represents one model, for which the dependent variable is listed on the left column of this table. All variables shown in descriptive statistics were also included in each model presented above. Standard errors were clustered by physician organization to account for non-independence between the same organization over time. Abbreviations: HIT, health information technology; EHR electronic health record. Data source: The cohort of medical groups responding to both the National Study of Physician Organizations II (March 2006 - March 2007) and the National Study of Physician Organizations III (January 2012 – ongoing; data from responses up to March 2013).

Table 19: Support for hypotheses: Large medical groups

H1	Physician organizations owned by hospitals, health systems, or HMOs will be more likely than independently owned organizations to adopt HIT early on than other organizations.
	No support. Ownership was not associated with the early adoption of any measures of HIT.
H1a	Physician organizations owned by hospitals, health systems, or HMOs will be more likely than independently owned organizations to adopt externally oriented HIT early on, especially to the extent that functionalities improve communication with those external entities.
	No support. Ownership was not any more strongly associated with the early adoption of the externally oriented index than with the internally oriented index.
H1b	As adoption of a given measure of HIT increases over time, due to increased imitation pressures, the association between ownership and the adoption of HIT will diminish.
	No support. The association between ownership and the later adoption of HIT neither diminished nor strengthened over time.
H2	Physician organizations affiliated with an independent practice association or a physician-hospital organization will be more likely than others to adopt HIT early on.
	No support. affiliation with an IPA/PHO was not associated with the early adoption of any measures of HIT.
H2a	As adoption of a given measure of HIT increases over time, due to increased imitation pressures, the association between affiliation with an IPA/PHO and the adoption of HIT will diminish.
	No support. The association between affiliation with an IPA/PHO and the later adoption of HIT neither diminished nor strengthened over time.
H3	Organizations reporting the opportunity to receive bonus income from the adoption or use of HIT early on may be more likely to have adopted HIT early on than other organizations.
	Strong support. The opportunity to receive bonus income for the adoption or use of HIT was strongly associated with the early adoption of six of ten measures of HIT, including both the internally oriented and externally oriented indices.
H3a	As the Meaningful Use program is implemented, the association between direct incentives and the adoption of HIT will diminish.
	No support. The association between the opportunity to receive bonus income for the adoption or use of HIT and the later adoption of HIT neither diminished nor strengthened over time.
H4	Organizations exposed to incentives for outcomes other than the adoption of HIT but for which HIT may indirectly make easier to achieve may be more likely to have adopted HIT early on.
	Weak support. The opportunity to receive bonus income for quality/efficiency was associated with the early adoption of only one of the measures of HIT – the registries index.
H4a	As the Meaningful Use program is implemented, the association between indirect incentives and the adoption of HIT will diminish.
	No support. The association between both measures of indirect incentives and the later adoption of HIT neither diminished nor strengthened over time.

4C. RESULTS: COMPARISON OF SMALL/MEDIUM-SIZED PRACTICES AND LARGE MEDICAL GROUPS

4C.1. Descriptive statistics

Small and medium-sized physician practices adopted HIT at much lower rates than larger medical groups. In both the 2006/2008 and the 2012 survey periods, smaller practices had adopted around 20 percentage points fewer HIT functionalities (in 2006/2008: 30 percent vs. 50 percent; in 2012: 43 percent vs. 69 percent) (**Tables 5a and 5b**). This magnitude of difference was generally consistent across each of the sub-indices.

Additionally, with respect to their organizational characteristics, practice size was not the only difference between the two groups; small/medium-sized physician practices were much less likely to report being owned by a hospital, hospital system, or HMO than larger medical groups (in 2012, 17 percent of small and medium-sized reported being owned by a hospital/system/HMO, in comparison to 47 percent of medical groups) (**Tables 8a and 8b**). Larger medical groups were also more likely than small/medium-sized physician practices to participate in quality improvement programs (in 2012: 20 percent vs. 54 percent) or to use plan-do-study-act methods (in 2012: 15 percent vs. 52 percent). Thus, not only did large medical groups have the resource advantage and bargaining power gained from having many more physicians under one organizational umbrella, but they also were much more likely to have support from another entity that owned them and to be oriented towards improving the quality of care they were providing.

4C.2. Multivariate findings

This dissertation found, through multivariate analyses, that small/medium-sized practices and large medical groups adopted health information technology for very different reasons, even after controlling for similar sets of factors (**Appendix D**).

Hypotheses **H1** and **H1a**, regarding the effect of ownership by a hospital, health system, or HMO, were supported for the small/medium-sized practices, but not for the large medical groups. It is likely that the much smaller physician practices benefited more from ownership, because they likely had substantially lower access to resources (including financial resources, information, expertise, etc.) than the larger medical groups.

Similarly, Hypothesis **H2**, about the effect of affiliation with IPAs/PHOs, was also only supported for the smaller cohort of organizations, likely for the same reason. Simply, the large medical groups likely benefited much less from ties to other organizations, because their size enabled them to be more self-sufficient.

However, hypothesis **H3**, regarding the effect of direct incentives (as measured by the opportunity to receive bonus income for the adoption or use of HIT) was strongly supported for organizations in both the small and large cohorts. For both, the opportunity to receive bonus income for the adoption or use of HIT was associated with large increases, of around 10 percentage points, in the overall HIT index in the early period (2006 or 2008).

Hypothesis **H4** posited that indirect incentives – as measured by public reporting of data on quality and/or efficiency and the opportunity to receive bonus income for quality and/or efficiency – would be associated with the early adoption of HIT. For organizations in both cohorts, the opportunity to receive income for quality/efficiency was not consistently associated with the adoption of HIT in the early period. This was surprising, because it was

expected that organizations facing the opportunity to earn bonus income for quality or efficiency would use HIT to achieve those goals. Additionally, while the public reporting index was not measured for the large organizations, it was associated with the overall HIT index for small organizations in the early period, as hypothesized.

Regarding changes over time, small/medium-sized practices that were larger that were owned by a hospital/health system/HMO, and that had a stronger quality orientation (as measured by the patient-centered management index, participation in a QI program, and use of plan-do-study-act) were much more likely to have been later adopters of HIT. Notably, the associations of these indicators with the later adoption of HIT increased in magnitude over time, as the conditions around the adoption of HIT also shifted. This suggests that small, independently owned organizations lacking a strong quality orientation were much less likely than others to have the capabilities and motivation needed to respond to changes in their environment.

In contrast, the large medical groups appeared to have all increased their adoption of HIT, across the board, especially for the electronic health record functionalities and electronic prescribing, which were both required for the Meaningful Use Stage 1 criteria.

4C.3. Summary

In summary, there were several notable fundamental differences between the two cohorts of physician organizations in this analysis. The small organizations were much less likely than large organizations to be owned by hospitals/systems/HMOs or to be oriented towards quality improvement.

Additionally, for organizations in both cohorts, practice size was an important capability for the adoption of HIT, and direct incentives were strong motivators to adopt. However, quality orientation and organizational ties played a much stronger role for the small organizations than the large organizations.

5. DISCUSSION OF FINDINGS AND IMPLICATIONS

5.1. Discussion of findings

Drawing on survey data from two cohorts of physician organizations, this dissertation provided national results on the adoption of health information technology (HIT) over time: from 2008 and 2012 for a cohort of small and medium-sized physician practices, and from 2006 and 2012 for a cohort of large medical groups. In particular, this dissertation has addressed three gaps in the literature on the adoption of health information technology, by (1) analyzing ten measures of HIT adoption that reflected how HIT was adopted by physician organizations located throughout the US; (2) exploring the role of organizational ties and incentives in the decision to adopt HIT; and (3) using longitudinal methods to examine trends over time.

Adoption of health information technology

Adoption increased substantially over time. Adoption of most HIT functionalities was quite low in the first period that each cohort of organizations was surveyed, especially for the cohort of small/medium-sized physician practices. However, for organizations in both cohorts, the adoption of HIT functionalities increased substantially over time, by about 20 percentage points overall between the first and second survey periods.

Among small/medium-sized physician practices, on average, practices had only adopted 30 percent of internally oriented functionalities in the first period (2008), but 50 percent of functionalities, on average, had been adopted by the second period (2012). Functionalities in the electronic health record (EHR) index showed an especially great increase in prevalence between 2008 and 2012, from an adoption rate of 26 percent, on average, to 59 percent.

Large medical groups also demonstrated large increases in the adoption of HIT between 2006 and 2012, from 43 percent of all functionalities adopted on average to 69 percent. Additionally, as with the small/medium-sized physician practices, the prevalence of EHR functionalities among large medical groups increased especially substantially; 46 percent of EHR functionalities were adopted in 2006, on average, in comparison to 87 percent in 2012.

Measures of health information technology. This dissertation also explored patterns in the clustering of adopted HIT functionalities; to my knowledge, this is the first analysis of adoption patterns from a national sample of physicians or physician organizations. Patterns of clustering among HIT functionalities existed in the adoption of HIT functionalities by physician organizations. These patterns were remarkably consistent across time and organizational size, suggesting that physician organizations do not perceive health information technology primarily as one grand construct, but rather see HIT as an array of functionalities with varying levels of cost, utility and complementarity with the other functionalities. For example, although both the electronic health record functionalities and registries functionalities were internally oriented, functionalities in each sub-category were weakly correlated across categories but strongly correlated with other functionalities within each category. With the exception of hospital discharge summaries, emergency department notes and laboratory results, the externally oriented functionalities were even less cohesive, suggesting that they tended to be adopted through separate ad hoc decision processes.

Comparison with rates of adoption found in prior research. The measures for the adoption of HIT used in this study were not directly compatible to those reported in other recently published studies for several reasons. For one, the availability of survey items

reflecting the adoption of HIT functionalities differed across surveys. For example, in their measures of electronic health records, DesRoches et al. (2008) included, among others, the functionalities of viewing imaging results and including patient demographics, which were not available from the surveys used for this study. Likewise, this study contained unique and important information on functionalities not included in other surveys, such as whether organizations had the capability to connect their electronic health record to that of their main hospital. Additionally, this study used survey data from organizations, while nearly all other studies on the adoption of health information technology used physician-level data. Because of this difference in the unit of analysis, national rates between this and other physician-level surveys will not be comparable.

Additionally, as noted above, this study developed measures of health information technology that actually reflected how HIT had been adopted. In contrast, many prior studies have used binary measures, specified according to what a panel of experts (Blumenthal et al. 2006; RWJF 2008) believed an electronic health record should include in order to be considered a "basic" or "fully functional" EHR system (e.g., DesRoches et al 2008; Decker et al 2012; Hsiao et al. 2011; Hsiao et al. 2012). Still others have used perhaps the simplest measure for the adoption of HIT, whether the respondent reported having adopted any sort of electronic health record system (Decker et al 2012; Menachemi et al. 2007a, 2011, 2012; Singh et al. 2012). Some studies have analyzed several functionalities without aggregating them (Hogan et al. 2012; Menachemi et al. 2007b). A recent study also developed a binary measure of adoption reflecting the criteria required to achieve the first stage of Meaningful Use from items available in the National Ambulatory Medical Care Survey (Patel et al. 2013). To my knowledge, only one prior study used a continuous index measure – the approach taken by this study – in examining the adoption of HIT (Robinson et al. 2009).

Nonetheless, the findings from this study were generally consistent with other studies. Both the moderate rates of adoption for physician organizations prior to Meaningful Use policy and the large increases since, especially for small/medium-sized physician practices, are consistent with other literature published on the adoption of health information technology (DesRoches et al. 2008; Gans et al. 2005; Robinson et al. 2009; Hsiao et al. 2011; Wright et al 2013). Drawing from data collected during late 2007 and early 2008, DesRoches et al (2008) reported that only 13 percent of physicians responding to their national survey had adopted even a basic EHR system. Although this is much lower than the 36 percent of practices responding to the National Study of Small and Medium-sized Physician Practices that reported having adopted an EHR, DesRoches et al's "basic" measure also required the adoption of electronic prescribing and other external functionalities. Additionally, Decker et al. (2012) reported that 54.2 of the physicians responding to the National Ambulatory Care Medical Survey had adopted any EHR by 2011, much lower than the 69 percent small/medium-sized practices reporting that they had any functionalities in 2012 found by this study. However, the adoption rate of 69 percent reported in this study will likely decrease once results are weighted to reflect the survey sampling frame (weights were not available at the time of the initial analysis). Additionally, Decker et al. (2012) found that rates of adoption were higher (59 percent) among primary care physicians than among specialtists, and primary care practices consisted of the majority of physician organizations this study. Thus, were the samples of respondents for each study more closely matched, it is likely that results would be very similar.

Adoption rates varied across types of HIT. In 2008, small/medium-sized physician practices had only adopted 22 percent of all internally oriented functionalities on average, with uptake of chronic disease registries being especially low (only 15 percent). In contrast, certain externally oriented functionalities were relatively common; even in 2008, over 75 percent of practices had adopted electronic access to laboratory tests, emergency department notes, and hospital discharge summaries. By 2012, rates of adoption for these three functionalities still remained substantially greater than others in the cohort of small/medium-sized physician practices. This suggests that, even in 2012, many practices used these functionalities as standalone features, without also having adopted any of the electronic documentation functions central to electronic health records. These results are thus consistent with recent reports that many practices still use multiple specialized software packages to accomplish different tasks rather than one comprehensive, integrated information technology system (Grossman et al 2007; Grossman et al 2012; Crosson et al. 2012; Jariwala et al 2013). Although standalone functionalities, such as software packages enabling electronic prescribing or electronic viewing of laboratory results, may be relatively easy to adopt, integrating data from them into patient records has been cited as a challenge of using a patchwork of software systems (Grossman et al 2007; Crosson et al. 2012).

Connecting the electronic health record to that of the main hospital occurred especially infrequently. Both small/medium-sized physician practices large medical groups rarely connected their EHR to that of their main hospital. By 2012, only 16 percent of small/medium-sized physician practices and 35 percent of large medical groups had adopted this capability. The level of these rates is notable, because this capability more than any others in this study indicates that physician organizations had the ability to use their HIT systems for robust care coordination. However, it is likely that these rates will continue to increase, as hospitals also continue to adopt more sophisticated HIT systems (DesRoches et al 2012; Charles et al 2013).

Key factors associated with the adoption of health information technology

Over time and across the small/medium and large organizational cohorts, the external factors highlighted in this study – organizational ties and incentives – were not consistent in their influence on the adoption of HIT. Nonetheless, some clear trends emerged and are discussed below.

Organizational ties. Ties to other organizations were strongly associated with the adoption of HIT by organizations within the cohort small/medium-sized physician practices, but were not associated at all with adoption for the cohort of large medical groups. In particular, for the small/medium-sized practices, both measures of organizational ties (ownership by a hospital/system/HMO and affiliation with an IPA/PHO) were associated with the adoption of the interoperability index early on in 2008. Likewise, two measures (ownership and affiliation with an IPA/PHO) were associated with the early adoption of connecting the EHR to that of the main hospital. These results lend support for the hypothesis that organizational ties will especially be associated with the early adoption of externally oriented functionalities, especially to the extent that they improve electronic communication between healthcare organizations.

In looking at later adoption, in 2012, it was initially hypothesized that the influence of organizational ties would diminish as the conditions around the adoption of HIT shifted (e.g., as the meaningful use incentives were implemented and the quality of the technology improved),

potentially making HIT more accessible for a broader set of organizations. However, the strength of the associations between ownership and several measures of HIT actually increased. This suggests that independently owned small/medium-sized physician practices may have lacked the capabilities and motivation needed to respond to changes in their environment.

The findings of this study around the role of ownership have also been echoed by other recently published studies. Using data from the National Ambulatory Medical Care Survey, Decker et al (2012) reported that physicians in physician-owned practices were less likely to adopt an EHR by 2002 and were also substantially less likely to adopt an EHR since, concurring with this study that the adoption gap has moderately widened. Additionally, in their physician-level study using data from the National Ambulatory Medical Care Survey (NAMCS) for the years 2008-2011, Patel et al. (2013) also found that physicians in practices owned by an HMO were much more likely to have adopted an electronic medical record meeting the Meaningful Use criteria. The findings around ownership from the present study, Patel et al. (2013) and Decker et al (2012) provide strong evidence that small, independently owned physician practices were less likely than those owned by a larger entity to respond to the Meaningful Use incentives and other changes over time related to the adoption of HIT.

Additionally, this finding can be interpreted in multiple ways; one is that ownership, like practicing in a larger medical group, is another way of achieving the scale necessary to motivate adopting an HIT system. However, this dissertation argues that there is also another potential reason that small and independently owned practices may be lagging with the adoption of HIT: maintaining their autonomy and independence. These smaller practices may be especially reluctant to adopt an HIT system that is compatible with only some of their partners or that may restrict future strategic decisions. The interpretation of this finding is important because the nature of the interpretation affects the implications for policy. Future qualitative research is needed to solidify this interpretation, and whether the relevant story here is about resources, maintaining independence, or likely a combination of both.

Incentives. Both direct and indirect incentives were often associated with the adoption of health information technology. However, as hypothesized, and consistent with prior research on the effect of incentives on adoption (Robinson et al. 2009), direct incentives for the adoption or use of HIT were more frequently associated with the adoption of HIT and with a greater magnitude than were indirect incentives for quality/efficiency. In particular, for both the smaller and larger cohorts, direct incentives were strongly associated with the electronic health record index in the first period and with connecting the EHR to that of the main hospital. These effects were very large, frequently over ten percentage points in both cases. However, for the cohort of large medical groups, direct incentives had relatively minimal effects on later adoption, perhaps because of ceiling effects – that the effects of incentives had already played out or that relevant HIT functionalities had already been adopted.

The large effects associated with these incentives measured by this study are consistent with prior research showing the importance of resources and concerns about profitability for the decision to adopt HIT systems (Rao et al 2011; DesRoches et al 2008; Gans et al 2005; Robinson et al 2009; Felt-Lisk et al 2012). These findings also suggest that meaningful use policy may push physicians that were “on the margin” to make the decision to adopt HIT. One important limitation to causally interpreting these findings is that it is unclear whether

incentivized practices had previously adopted HIT and were opting into the incentive programs having already met the conditions, or whether the findings herein truly reflect responses to the incentives. As Rosenthal et al (2006) argued, in most cases, the likely explanation is that incentive programs enrolled mostly practices that were likely to adopt HIT regardless of the incentives. This concern about selection into incentive programs is magnified by the finding that 43 percent of the practices enrolled in a recent demonstration trial of the effects of financial incentives on the adoption of EHRs dropped out of the program (Felt Lisk 2012). This is also a concern about the effects of the meaningful use program; that physicians already planning to adopt will benefit from the incentive, while providers not planning to adopt will ignore the incentive, with perhaps relatively few physicians actually "on the margin."

Indirect incentives, as measured by the public reporting index and the income for quality/efficiency index, were moderately associated with the early adoption of registries for both cohorts. This suggests that practices participating in public reporting programs may have felt that registries would help improve their quality of care. Still, reverse causation remains a possible limitation for this finding; it is possible that practices that had already adopted registries were more likely to enroll in public reporting or pay for performance programs.

Other findings of interest

Practice size. As has been frequently discussed in prior literature (DesRoches et al. 2008; Gans et al. 2005; Robinson et al. 2009; Hogan and Kissum 2010), this dissertation again found that practice size was strongly associated with the early adoption of HIT, in the first periods, among both small/medium-sized physician practices and large medical groups. This effect was consistently very large across nearly all measures of HIT.

For late adoption, practice size was minimally associated with the adoption of HIT, potentially reflecting ceiling effects – that larger physician organizations had already adopted many or even most HIT functionalities. The lack of a finding associated with practice size suggests that, in the second period, physician organizations adopted HIT at the same rate, regardless of the size of their practice.

Still, even in 2012, many very small physician practices, were still holding out from adopting any electronic health record and electronic prescribing functionalities. As Adler-Milstein, Green and Bates (2013) recently reported, especially these very small practices may hold out from adopting robust HIT, even in the face of Meaningful Use incentives, because the $44,000 that most providers were eligible to receive from the Meaningful Use program may not be enough to make these implementing these functionalities profitable in the short run.

Quality improvement orientation. This dissertation also found associations between adoption of HIT and measures capturing the quality improvement orientation of physician organization, especially for the cohort of small/medium-sized practices. Small and medium-sized practices reporting that they used plan-do-study-act methods were more likely than other practices to adopt both internally and externally oriented functionalities in 2008 and scored over eight percentage points higher on the overall HIT index after controlling for other factors. Adoption of HIT may help facilitate plan-do-study-act quality improvement cycles by enabling easier access to data (Fullerton et al. 2006), and practices using plan-do-study-act methods may have also been more likely to know when additional HIT would prove useful.

Likewise, practices involved in quality improvement programs were also more likely to adopt EHR and registries functionalities by 2008; while causation cannot be determined, it is possible that these practices were motivated to adopt EHRs in order to collect information more systematically for their quality improvement efforts (Bradley et al. 2004).

Together, these results suggest that, for the cohort of small/medium-sized physician practices, both early and later adopters of HIT tended to be internally motivated to adopt HIT. These practices may have been more likely to see potential benefits from adopting HIT, such as achieving greater efficiency in the everyday routines of their practice and developing mechanisms for faster feedback related to evaluating the cost and quality of their care.

Unlike the small/medium-sized practices, the two available measures of quality orientation (patient-centered management index and participation in a QI program) were not at all consistently associated with either early adoption or later adoption of HIT. This is perhaps not as surprising when considering how the decision-making processes likely differed between very small physician practices and the much larger medical groups; while smaller organizations are frequently driven by charismatic leaders, larger organizations typically develop bureaucratic processes through which "rational" decisions are made (Weber 1946). From this logic, it makes sense that the small and medium-sized physician practices would be more likely to have been guided by their values than larger organizations.

5.2. Implications for policy and practice

These findings suggest that different policy levers might be used to encourage the adoption of internal versus external functionalities. The association of practice size and direct incentives with the adoption of internally oriented HIT is consistent with the view that practices with more resources and practices facing stronger incentives will be more capable and motivated to adopt HIT (DesRoches et al. 2008; Rao et al. 2011; Robinson et al. 2009; Felt-Lisk et al. 2012). This view was also reflected in the design of the Meaningful Use incentive program, which provides financial incentives to individual physicians (Centers for Medicaid and Medicaid Services 2011).

Alternatively, an especially strong association was found between organizational ties (e.g., ownership and affiliation with IPAs/PHOs) and the adoption of externally oriented HIT for the cohort of small and medium-sized practices. This suggests that small/medium-sized practices were most likely to adopt these functionalities when organizational arrangements facilitated health information exchange. This was especially clear from the very large association between ownership by a hospital/system/HMO and having an EHR that is connected to practices' main hospitals – perhaps the strongest measure of electronic integration into a larger healthcare system in this study.

Generally speaking, policy makers are certainly aware of these trends and the need to improve the prevalence of electronic information exchange (Centers for Medicaid and Medicaid Services 2013). For example, the Stage 2 Meaningful Use criteria require that providers: use computerized provider order entry for medication, laboratory and radiology orders; reconcile medications with other providers when necessary; and provide a summary care record for each transition of care or referral to new settings or providers of care. Notably, the third criteria above requires that providers electronically send relevant patient information to other providers. Additionally, the HITECH Act provided $564 million total to states (distributed in

2010) as funding for the support or establishment of health information organizations (HIOs) (Bostick, Crayton and Fishman 2011), to help develop health information exchange capabilities.

The empirical results reported in this dissertation lend support for these ongoing initiatives and arguably suggest that more might be able to be done to facilitate and motivate stronger health information exchange. In particular, policies that enabled and encouraged healthcare organizations to cooperate with one another may be a particularly effective means to stimulate the adoption of externally oriented functionalities enabling electronic integration into broader systems.

For example, an incentive to adopt externally oriented HIT could be provided to both hospitals and physician practices, on the condition that both organizations adopt those functionalities. By aligning the interests of separate entities to be commonly oriented towards electronic integration, a "joint incentive" or community-level incentive could provide a framework for organizations to begin working together towards a mutually beneficial outcome. Perhaps the most important effect of such an incentive would likely be to make the joint component of the adoption decision more salient for leaders of organizations. As Wageman (1995) showed in a micro-organizational study of group effectiveness under individual-oriented and group-oriented reward system designs, group-oriented incentives dramatically increased the effectiveness of teams in completing group-oriented tasks.

Additionally, supporting the development of more robust regional health information organizations (RHIOs) (Adler-Milstein, Bates, and Jha 2011; Maxson et al 2010; Bostick, Crayton and Fishman 2011) may help independent physician practices work with other healthcare organizations in their community. Unfortunately, in recent years, as Adler-Milstein et al (2010, 2011) have reported, regional health information organizations have not received funding adequate to fulfill their mission of improving health and care in that community throughout communities through health information exchange (Health Resources and Services Administration 2013). With additional federal support, RHIOs might be better able to reach out to those small, independent physician practices most needing external support to adopt HIT, especially HIT facilitating robust electronic exchange of clinical information.

Accountable care organizations (ACOs), in which physicians, hospitals, and other clinicians and health care organizations explicitly work together in providing care to a defined population of patients (McClellan et al. 2010), might also motivate independent practices to adopt the externally oriented HIT, in order to be able to exchange health information with other organizations in the ACO. This is especially the case because HIT will likely be a key capability held by successful ACOs (Singer and Shortell 2010; Shortell and Casalino 2010). Additionally, as with the prior two examples of policies to increase the adoption of HIT by physician organizations, ACOs may provide a platform for independent physician organizations to begin discussions with other entities around how to best use HIT to facilitate care coordination across organizational boundaries, especially to the extent that ACOs facilitate the broadening of providers' social identities to the community level rather than at the organization level (Kreindler et al. 2012).

5.3. Implications for future research

The current study also has implications for the measurement of HIT in future research. Many prior studies of the adoption of HIT have examined adoption using binary measures,

indicating that an EHR was, for example, a "Basic EHR System" or a "Fully Functional EHR System" (DesRoches et al. 2008; Hsiao et al. 2012). While these binary measures reflect an expert consensus of the functionalities required for an EHR to be fully functional (Blumenthal et al. 2006), smaller physician practices in particular, especially early on, did not adopt HIT in a manner captured by these categories. For example, in contrast to the large medical groups with 20 or more physicians (Robinson et al. 2009), small and medium-sized practices frequently adopted electronic access to laboratory tests, emergency department notes, and hospital discharge summaries in both survey periods (2008 and 2012) without also adopting any of the electronic documentation functions considered central to basic electronic health records. Capturing such nuances in the landscape of the adoption of HIT by physician organizations in future studies may help policy makers better understand where progress has already been made and where help is most needed. Thus, future studies of the adoption of HIT should consider using more granular and/or continuous measures.

Future studies might also take into consideration a broader set of explanatory factors and that the effect of factors may change over time. Although many prior studies have emphasized the importance of practice size and other proxies capturing access to resources, this is not necessarily the only – or even the most important – factor with respect to the adoption of HIT. Especially as the characteristics of non-adopters increasingly lean towards small and independently owned practices, future studies might emphasize which other characteristics, among this subset of organizations, seem to be facilitating adoption. Additionally, while Decker et al. (2012) nicely incorporated in their recent study that the effects of factors may be changing over time, most prior studies on the adoption and use of HIT have not explicitly recognized that the not only are the characteristics of non-adopters changing (as more and more practices come to adopt HIT), but also that physician practices are situated in complex and changing environments.

More broadly, the impact of HIT relies not only on whether healthcare providers and organizations adopt and use IT functionalities, but also on the intensity of use by providers in an organization and how functionalities are used. As Dr. David J. Brailer, a former leader of the Office of the National Coordinator for Health Information Technology (ONC), recently stated in the New York Times: "The vast sum of stimulus money flowing into health information technology created a 'race to adopt' mentality — buy the systems today to get government handouts, but figure out how to make them work tomorrow" (Abelson and Creswell 2012). As rates of adoption approach 100 percent in the coming years, the next challenge around HIT will be facilitating providers' use of HIT. For example, prior work has shown that not all physicians have used functionalities even once adopted by their organization (Rao et al. 2011; McClellan et al. 2013; Lanham, Leykum and McDaniel 2012). Likewise, providers may not be using functionalities to their maximal capabilities. For example, even if a physician organization has the capability to electronically coordinate with their main hospital, what about when a patient sees another hospital across town with which the organization does not have a data-sharing agreement? Even if the technical capability to coordinate care exists, dynamics around the sharing of patient health information may be regulated by complex logics of collaboration and competition, in which patient information is often seen by healthcare providers and organizations as a valuable resource (Adler-Milstein, Bates, and Jha 2011; Adler-Milstein and Jha 2012; Grossman, Kushner, and November 2008). Such a study might map patterns of

electronic health information exchange using social network methods, following recent work on physician networks using shared patients to indicate ties (Barnett et al. 2011; Landon et al. 2012) and longstanding work about referral relationships (Shortell 1973).

Finally, ultimately, health information technology is only important, from a policy perspective, to the extent that it assists with improving healthcare quality/outcomes and lowering costs. Substantial early work has been done identifying the effects of HIT on costs (CBO 2008; Shekelle et al 2006; Kellermann and Jones 2013; Chaudhry et al 2006) and quality/outcomes (Buntin et al. 2011; Blumenthal and Tavenner 2010; Reed et al. 2012; Romano and Stafford 2011; Costa et al 2009; Cebul et al 2011), but future studies could do more in identifying the benefits of HIT for specific populations and how to optimize existing systems. In particular, one key methodological concern is that providers using HIT in more sophisticated ways may differ from other providers in ways difficult to measure using conventional methods, potentially confounding findings. Methods such as propensity score matching or instrumental variables may be needed to adjust for this concern.

5.4. Limitations

This study has several limitations. One major limitation of survey research, in general, is that survey researchers can only examine topics for which survey data is available. For example, it is unknown whether physician organizations had the capacity to electronically exchange clinical information with other providers, outside of hospitals. However, by aggregating available survey items into indices, this study was able to capture broad variation in the adoption of health information technology, thereby negating some of these concerns. As well, because they surveys used for the study were conducted at the organizational level, information on provider characteristics was not available, potentially biasing results. For example, provider age has been shown in recent studies to be moderately negatively associated with the adoption of HIT (e.g., Decker et al 2012; DesRoches et al 2008). To the extent that provider age was also associated with practicing in hospital/system/HMO-owned organizations, then the findings reported for the association between ownership and the adoption of HIT by small/medium-sized practices might be positively biased.

Second, this study is only generalizable to the years in which data was available; 2008 and 2012 for the small/medium-sized physician practices, and 2006 and 2012 for large medical groups. That data for both cohorts of physician organizations was limited to two time points restricts the ability to examine specific patterns in the adoption of HIT over time, such as whether the adoption of certain functionalities led to the adoption of others. Additionally, because these analyses were not weighted to reflect the complex design of the sampling frame, these analyses may have limited external validity. However, the study included physician organizations with a great diversity of organizational characteristics and which were located across the US in areas with varied market conditions.

Third, another common limitation of survey research is that specific mechanisms cannot often be identified when looking to explain effects that have been discovered. For example, additional qualitative research is needed to identify why hospitals, systems and HMOs were so strongly associated with the adoption of functionalities enabling information exchange; whether the explanation lies in the provision of additional resources and technical assistance, in coercion, or another reason cannot be determined in this study. For example, it is possible that

physician organizations owned by larger entities had an easier time overcoming concerns about patient privacy and/or regulatory issues related to the the Health Insurance Portability and Accountability Act of 1996 (HIPAA), by sharing patient information within a defined system.

Fourth, it is possible that practices that did not respond to the survey differed from those that did. However, both the National Survey of Physician Organizations II and the National Survey of Small and Medium-sized Physician Practices had relatively high response rate (respectively, 60 and 63 percent). For both studies, estimates for adoption rates of electronic health records were comparable to other national surveys of physicians conducted at the same time. Additionally, differences between responders and non-responders to the National Survey of Small and Medium-sized Physician Practices were minimal across practice size and specialty type (**Appendix A**), thus reducing – although not eliminating – concerns about non-response bias.

In contrast, concerns about non-response bias from the National Survey of Physician Organizations III are moderately stronger. The response rate at the time data were extracted was 43 percent. In the analysis of differences between responders and non-responders, non-responders were more likely to have between 13 and 99 physicians than responders. Non-responders were also more likely to be cardiology practices and to not have responded to a prior survey. However, for both the cohorts of small/medium sized practices and large medical groups, very minimal differences were found between organizations that responded to only surveys fielded previously (in 2008 and 2006, respectively) and those also responding to the National Survey of Physician Organizations III on the measures of HIT (**Tables 8a,b and 10a,b**) or on the organizational characteristics and external factors (**Tables 11a,b**), thus moderating to some extent concerns about non-response bias. Still, it is possible that responders to the National Survey of Physician Organizations III were systematically more likely to have adopted HIT than non-responders; if so, the rates of HIT adoption reported in this study would be positively biased.

Finally, the study designs used herein allow for inferences of association but not causation. Although the study makes a strong effort to control for a broad range of factors, the threat of omitted variable bias remains. For example, physician-level factors, such as age, have been shown to be associated with the adoption of HIT (DesRoches et al. 2008), but could not be included in the study.

6. CONCLUSIONS

To conclude, large medical groups have by and large adopted relatively comprehensive HIT systems, and small/medium-sized practices doing less but are still making progress. As with previous research, practice size and incentives were also found to be crucial factors for the adoption of HIT in this study. However, these factors and the access to resources they represent were not the only or even always the most important factors to consider. Ties to other organizations and the quality improvement orientation of organizations were also frequently and strongly associated with the adoption of HIT.

This study also demonstrated, for the first time, that different factors were associated with the adoption of different sets of HIT functionalities. In particular, for smaller physician practices, organizational ties – as measured by ownership by a hospital, health system, or HMO and affiliation with an independent practice association or physician-hospital organization – were especially strongly associated with the adoption of externally oriented HIT functionalities facilitating tighter clinical integration with other organizations. To develop the capacity for strong electronic interoperability, especially smaller and independently owned physician practices may need to develop closer ties to hospitals and health systems. Still, one danger of relying on strong organizational ties is that, if these trends continue, the health system may develop such that electronic health information exchange occurs only within existing networks of healthcare organizations, but not necessarily between them.

However, several new trends among healthcare organizations offer hope for a system where care coordination can truly occur as needed. Emergent organizational forms such as accountable care organizations, Oregon's Coordinated Care Organizations, and regional health information organizations may be able to bring healthcare organizations together to facilitate stronger care coordination.

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APPENDIX A. ANALYSIS OF NON-RESPONSE

In order to improve the assessment of potential non-response bias to the surveys of physician organizations used as the main data sources for this study, this dissertation employed multiple means of examining differences between respondents and non-respondents of the three surveys of physician organizations. As Halbesleben and Whitman (2012) discuss, such analyses are important, because "response rates are an incomplete assessment of survey data quality" (Halbesleben and Whitman 2012: p. 1). In particular, it is important to assess the extent to which respondents reflected the overall population in question (Halbesleben and Whitman 2012).

In attempting to do this, two methods were used, drawing upon available data. First, for two of the three surveys used (the National Study of Small and Medium-sized Physician Practices, and the National Study of Physician Organizations III), sampling frames were developed to randomly select a representative sample of the population of interest, based on organizational size, organizational specialty mix, and geographic location. For these two studies, information on those traits was available for both non-responders and responders, and that information was used to assess whether some kinds of organizations were systematically more likely to respond to the surveys than others. Unfortunately, for the National Study of Physician Organizations II, no information was available for non-respondents that were in the sampling frame, so the analysis could not be done for that survey. The results of this analysis are found below.

The second method used to assess non-response bias was to compare organizations responding to only one round of the study with those responding to both rounds of the study. For example, several organizations responding to the National Study of Small and Medium-sized Physician Practices were included in the sampling frame for the National Study of Physician Organizations III; thus, for these organizations, baseline data was available not just on practice size, specialty mix and geographic location, but on all questions included in the initial survey, including data on their initial levels of health information technology. Thus, these analyses demonstrate the extent to which practices that had adopted more HIT were also more likely to respond to the follow-up study. This analysis was conducted for both cohorts of organizations examined in this dissertation, and results from this analysis were presented in the results section (**Tables 5, 7 and 8**). The specifics for this analysis are discussed in the results section, but, in general, relatively few differences were found between responders and non-responders for both cohorts.

3.7. National Study of Small and Medium-sized Physician Practices

Although the response rate was high, multispecialty practices, pulmonology practices, and those not in communities targeted by Aligning Forces for Quality (AF4Q) were less likely to respond (**Table A1**). Still, there were no differences in response by size, and the Aligning Forces for Quality communities were spread across the US, meaning that no single areas was especially over sampled. Especially because of the importance of practice size for the adoption of health information technology, these results suggest that respondents are largely representative of the sampling frame, given the time period during which the survey was fielded (July 2007-March 2009). This analysis does not negate concerns related to non-response bias entirely, but does minimizes especially strong concerns.

Table A1: Differences in characteristics between responders and non-responders, National Study of Small and Medium-sized Physician Practices

	Non-respondent, mean % n=(826)	**Respondent, mean %** n=(1745)	**p-value**
Practice size			
1-2 physicians	38.98	37.31	0.415
3-7 physicians	36.56	36.16	0.844
8-12 physicians	14.04	16.10	0.169
13-19 physicians	10.41	10.32	0.940
Practice type			
Primary care[a]	9.69	9.23	0.712
Multispecialty[b]	13.08	9.57	0.011*
Cardiology[a]	13.68	13.12	0.700
Endocrinology[a]	6.17	4.81	0.166
Pulmonology[a]	11.14	8.02	0.015*
Practice location			
In an Aligning Forces for Quality community	61.86	68.77	0.001*

Notes: *P < 0.05. [a]At least 60 percent of physicians in each practice were of the focal specialty. [b]At least 30% of physicians in each practice were of primary care, multi-specialty, cardiology, or pulmonology, with no more than 60 percent from any single specialty. **Source:** IMS healthcare organizational services database, extracted in 2007 (IMS 2012a).

3.8. National Study Physician Organizations III

In contrast to the analysis for the National Study of Small and Medium-sized Physician Practices, responders to the National Study Physician Organizations III appeared to differ not only on practice specialty mix and location, but also on practice size (**Table A2**). In particular, practices with 13-99 physicians were relatively less likely to respond to the study, while practices with 3-7 physicians were much more likely to respond. However, differences in non-response across these basic characteristics are only a concern to the extent that the propensity to respond to the survey is also correlated with the outcome of interest (in this case, the adoption of HIT), which we cannot determine from this analysis. Still, the possibility remains that the estimates of the adoption of HIT in this study may be marginally positively biased.

Table A2: Differences in characteristics between responders and non-responders, National Study Physician Organizations III

	Non-respondent, mean % n=(1506)	**Respondent, mean %** n=(1161)	**p-value**
Practice size			
1-2 physicians	35.86	38.42	0.176
3-7 physicians	19.72	27.48	<0.001*
8-12 physicians	12.08	10.59	0.227
13-19 physicians	8.03	5.77	0.021*
20-99 physicians	20.58	14.47	<0.001*
100+ physicians	3.72	3.27	0.533
Practice type			
Primary care[a]	47.54	57.36	<0.001*
Multispecialty[b]	21.78	21.1	0.673
Cardiology[a]	18.79	11.71	<0.001*
Endocrinology[a]	5.05	4.05	0.217
Pulmonology[a]	6.84	5.77	0.258
Practice location			
In an Aligning Forces for Quality community	64.74	63.65	0.561
Prior respondent			
No prior response	37.85	15.76	<0.001*
Prior response, less than 20 physicians	54.25	74.16	<0.001*
Prior response, 20 or more physicians	7.9	10.08	0.053

Notes: *P < 0.05. [a]At least 60 percent of physicians in each practice were of the focal specialty. [b]At least 30% of physicians in each practice were of primary care, multi-specialty, cardiology, or pulmonology, with no more than 60 percent from any single specialty. **Source:** IMS healthcare organizational services database, extracted in 2011 (IMS 2012a).

APPENDIX B. COMPARISON AGAINST OTHER NATIONAL SURVEYS

Data from the National Survey of Physician Organizations II and the National Survey of Small and Medium-Sized Physician Practices (NSSMPP) were also compared against other national survey data available from the years the surveys were conducted (**Table B1**). Whether physicians or their practices had adopted an electronic health record was used as the primary item of comparison because the questions for this item were worded similarly across surveys. In general, estimates from the primary surveys used in this dissertation were largely consistent with estimates from the National Ambulatory Medical Care Survey (National Center for Health Statistics 2006, 2008) and Community Tracking Survey Physician Survey (Center for Studying Health System Change 2008). In particular, the estimate of practices that had adopted at least a "part electronic and part paper" electronic health record in 2008 were relative close between NSSMPP (36 percent) and the Community Tracking Survey (CTS) Physician Survey (43 percent). Unfortunately, a direct comparison could not be conducted between the surveys used herein and the National Ambulatory Medical Care Survey (NAMCS), because of a lack of information about practice size in the NAMCS public use file, and the CTS physician survey was not available in 2006.

Table B1: Comparison of rates of adoption of electronic health records in four national surveys

			By practice size	
	Survey type	All practices	Fewer than 20 physicians	20 or more physicians
Majority year survey in field: 2006				
National Ambulatory Medical Care Survey*	Physician-level	28.0	--	--
National Survey of Physician Organizations II*	Organizational-level	--	--	57.8
Majority year survey in field: 2008				
National Ambulatory Medical Care Survey*	Physician-level	46.8	--	--
Community Tracking Survey Physician Survey*	Physician-level	52.0	43.1	78.4
National Survey of Small and Medium-Sized Physician Practices*	Organizational-level	--	36.0	--
Majority year survey in field: 2012				
National Survey of Physician Organizations III**	Organizational-level	72.9	69.4	94.2

NOTES: All data taken from national surveys of physicians or physician organizations. For this table, adoption of electronic health records was measured as a binary (yes/no) variable. All survey estimates excluded responses from surgical, mental health and OB-GYN specialties. Data for empty cells was not available at all or in the public use file version of survey data. *Estimate weighted to be nationally representative. **Comparable data collected during 2011 or 2012 not publically available.

APPENDIX C: TABLES FROM THE FACTORS ANALYSIS OF HIT FUNCTIONALITIES

This appendix presents tables from the factor analysis of health information technology functionalities, including the results of the exploratory principal components analysis (**Tables C1, C2 and C3**) and the confirmatory factor analysis (**Tables C4, C5, and C6**).

Table C1: Principal components: HIT functionalities, Medical groups, 2006

Component	Eigenvalue	Difference	Proportion	Cumulative
1	7.536	4.968	0.419	0.419
2	2.568	0.984	0.143	0.561
3	1.583	0.640	0.088	0.649
4	0.943	0.124	0.052	0.702
5	0.819	0.125	0.046	0.747
6	0.693	0.050	0.039	0.786
7	0.643	0.062	0.036	0.821
8	0.582	0.097	0.032	0.854
9	0.484	0.112	0.027	0.881
10	0.373	0.040	0.021	0.901
11	0.333	0.058	0.019	0.920
12	0.274	0.008	0.015	0.935
13	0.266	0.022	0.015	0.950
14	0.243	0.013	0.014	0.963
15	0.230	0.021	0.013	0.976
16	0.209	0.037	0.012	0.988
17	0.173	0.125	0.010	0.997
18	0.047	.	0.003	1.000

Notes: N=321 medical groups. Data source: National Study of Physician Organizations II.

Table C2: Principal components: HIT functionalities, physician practices, 2008

Component	Eigenvalue	Difference	Proportion	Cumulative
1	5.856	3.072	0.325	0.325
2	2.784	0.711	0.155	0.480
3	2.073	1.024	0.115	0.595
4	1.049	0.108	0.058	0.653
5	0.941	0.092	0.052	0.706
6	0.849	0.079	0.047	0.753
7	0.770	0.102	0.043	0.796
8	0.668	0.152	0.037	0.833
9	0.516	0.047	0.029	0.862
10	0.469	0.060	0.026	0.888
11	0.409	0.017	0.023	0.910
12	0.392	0.054	0.022	0.932
13	0.337	0.045	0.019	0.951
14	0.292	0.058	0.016	0.967
15	0.234	0.061	0.013	0.980
16	0.174	0.063	0.010	0.990
17	0.110	0.034	0.006	0.996
18	0.076	.	0.004	1.000

Notes: N=1,736 physician practices. Data source: National Study of Small and Medium-Sized Physician Practices.

Table C3: Principal components: HIT functionalities, physician practices and medical groups, 2012

Component	Eigenvalue	Difference	Proportion	Cumulative
1	6.885	4.674	0.383	0.383
2	2.210	0.173	0.123	0.505
3	2.037	0.924	0.113	0.619
4	1.113	0.185	0.062	0.680
5	0.928	0.265	0.052	0.732
6	0.663	0.029	0.037	0.769
7	0.634	0.052	0.035	0.804
8	0.582	0.089	0.032	0.836
9	0.494	0.048	0.027	0.864
10	0.446	0.050	0.025	0.889
11	0.395	0.013	0.022	0.910
12	0.382	0.051	0.021	0.932
13	0.332	0.050	0.018	0.950
14	0.282	0.041	0.016	0.966
15	0.241	0.080	0.013	0.979
16	0.162	0.019	0.009	0.988
17	0.143	0.072	0.008	0.996
18	0.071	.	0.004	1.000

Notes: N=1,036 physician practices and medical groups. Data source: National Study of Physician Organizations, III (NSPO3).

Table C4 Factor loadings and unique variances: HIT functionalities, medical groups, 2006

HIT functionality	Factor1	Factor2	Factor3	Uniqueness
Ambulatory care progress notes	0.875	-0.046	0.008	0.232
List of patient medications	0.964	-0.086	-0.070	0.058
Problem list	0.968	-0.070	-0.092	0.050
Alerts for potential drug interactions	0.833	-0.039	-0.065	0.301
Alerts for abnormal test results	0.749	0.050	-0.047	0.435
Prompts at time of patient visit	0.720	0.094	-0.075	0.468
EHR used to measure quality	0.771	0.049	0.079	0.398
Registry: Diabetes	0.250	0.678	-0.019	0.477
Registry: Asthma	0.222	0.856	-0.114	0.206
Registry: Congestive heart failure	0.304	0.743	0.009	0.356
Registry: Depression	0.229	0.727	-0.054	0.416
Physician electronic prescribing	0.525	0.054	-0.019	0.721
Laboratory test results	0.492	0.018	0.484	0.523
Emergency department notes	0.488	0.059	0.675	0.302
Hospital discharge summaries	0.504	0.062	0.672	0.291
EHR connects to EHR at main hospital	0.599	0.040	0.417	0.466
Physicians use e-mail with patients	0.281	0.106	0.139	0.891
Patients can access part of EHR online	0.341	0.198	0.028	0.843

Notes: N=321 medical groups. Data source: National Study of Physician Organizations II.

Table C5: Factor loadings and unique variances: HIT functionalities, physician practices, 2008

HIT functionality	Factor1	Factor2	Factor3	Uniqueness
Ambulatory care progress notes	0.928	-0.034	-0.044	0.135
List of patient medications	0.944	-0.053	-0.072	0.100
Problem list	0.960	-0.031	-0.055	0.075
Alerts for potential drug interactions	0.751	-0.008	-0.007	0.436
Alerts for abnormal test results	0.714	-0.021	-0.005	0.489
Prompts at time of patient visit	0.727	0.005	0.043	0.469
EHR used to measure quality	0.689	-0.016	0.164	0.499
Registry: Diabetes	0.211	0.044	0.819	0.282
Registry: Asthma	0.157	0.047	0.774	0.374
Registry: Congestive heart failure	0.188	0.050	0.782	0.351
Registry: Depression	0.064	0.094	0.738	0.443
Physician electronic prescribing	0.474	0.038	-0.028	0.773
Laboratory test results	0.136	0.426	0.071	0.795
Emergency department notes	0.052	0.918	-0.060	0.151
Hospital discharge summaries	0.146	0.878	-0.056	0.205
EHR connects to EHR at main hospital	0.363	0.101	0.029	0.857
Physicians use e-mail with patients	0.071	0.055	0.024	0.991
Patients can access part of EHR online	0.235	0.029	-0.007	0.944

Notes: N=1,736 physician practices. Data source: National Study of Small and Medium-Sized Physician Practices.

Table C6 Appendix B: Tables B1, B2, and B3: Factor loadings and unique variances: HIT functionalities, physician practices and medical groups, 2012

HIT functionality	Factor1	Factor2	Factor3	Uniqueness
Ambulatory care progress notes	0.883	-0.090	-0.093	0.204
List of patient medications	0.936	-0.121	-0.093	0.101
Problem list	0.950	-0.125	-0.097	0.072
Alerts for potential drug interactions	0.865	-0.090	-0.035	0.243
Alerts for abnormal test results	0.698	0.004	0.094	0.504
Prompts at time of patient visit	0.727	-0.038	0.052	0.467
EHR used to measure quality	0.815	-0.027	0.070	0.330
Registry: Diabetes	0.417	0.030	0.649	0.404
Registry: Asthma	0.339	0.085	0.742	0.327
Registry: Congestive heart failure	0.357	0.121	0.696	0.373
Registry: Depression	0.274	0.063	0.665	0.479
Physician electronic prescribing	0.570	0.045	-0.023	0.673
Laboratory test results	0.341	0.427	-0.055	0.698
Emergency department notes	0.233	0.864	-0.070	0.195
Hospital discharge summaries	0.268	0.896	-0.073	0.121
EHR connects to EHR at main hospital	0.326	0.167	0.040	0.864
Physicians use e-mail with patients	0.148	-0.008	0.096	0.969
Patients can access part of EHR online	0.400	0.011	0.120	0.825

Notes: N=1,036 physician practices and medical groups. Data source: National Study of Physician Organizations, III (NSPO3).

APPENDIX D. COMPREHENSIVE RESULTS FROM REGRESSION ANALYSES

This appendix presents the complete results from the forty regression models examined for this dissertation, as specified in the Methods section.

D.1. Small and medium-sized physician practices: adoption by 2008

Table D1a: Effect of organizational characteristics and external factors on the adoption of HIT by 2008, small and medium-sized physician practices, results from cross-sectional linear regression

	Overall HIT index	Internally oriented HIT index	Electronic health record index	Registries index
Practice size, log	5.146 [3.643,6.648]**	6.691 [4.908,8.474]**	9.369 [6.679,12.060]**	1.916 [0.337,3.496]*
Specialty mix: Multispecialty (ref: prim. care)	-3.987 [-9.526,1.553]	-6.115 [-15.716,3.486]	-8.446 [-20.513,3.622]	-2.086 [-10.860,6.687]
Specialty mix: Specialty (ref: prim. care)	0.376 [-2.005,2.757]	-1.599 [-4.426,1.229]	-0.751 [-5.475,3.972]	-3.772 [-6.778,-0.767]*
Minority patients, %	-0.014 [-0.085,0.056]	-0.045 [-0.135,0.045]	-0.053 [-0.162,0.057]	-0.034 [-0.132,0.063]
Patient-centered management index (0-5)	0.838 [0.299,1.377]**	1.120 [0.293,1.947]*	0.879 [-0.214,1.972]	1.593 [0.672,2.514]**
Participated in QI program	4.436 [1.388,7.484]**	6.673 [2.371,10.975]**	5.917 [0.988,10.846]*	8.094 [3.656,12.531]**
Used plan-do-study-act	8.319 [4.727,11.910]**	10.246 [5.957,14.534]**	8.521 [0.726,16.316]*	13.327 [8.440,18.213]**
Revenue: Medicare (ref: commercial)	-0.096 [-0.159,-0.033]**	-0.176 [-0.266,-0.087]**	-0.230 [-0.356,-0.104]**	-0.080 [-0.171,0.010]+
Revenue: Medicaid (ref: commercial)	-0.030 [-0.131,0.070]	0.008 [-0.137,0.153]	-0.030 [-0.244,0.183]	0.077 [-0.075,0.230]
Revenue: Uninsured (ref: commercial)	-0.094 [-0.165,-0.024]*	-0.108 [-0.191,-0.025]*	-0.167 [-0.287,-0.046]*	-0.004 [-0.091,0.083]
Revenue: Other (ref: commercial)	0.011 [-0.099,0.120]	0.075 [-0.049,0.199]	0.068 [-0.095,0.231]	0.085 [-0.037,0.207]
Ownership: Hospital/system/HMO (ref: phys.)	5.214 [0.372,10.055]*	2.666 [-2.977,8.309]	3.016 [-3.116,9.148]	2.230 [-3.879,8.339]
Ownership: Other (ref: physician owned)	0.444 [-7.438,8.325]	2.377 [-7.725,12.478]	0.808 [-14.780,16.397]	5.226 [-2.143,12.595]
Received patients from an IPA/PHO	1.849 [-1.377,5.076]	1.050 [-3.397,5.497]	-0.783 [-6.782,5.217]	4.181 [0.992,7.369]*
Public reporting index (0-2)	2.436 [1.137,3.735]**	3.090 [0.993,5.188]**	2.081 [-0.686,4.849]	4.821 [2.827,6.815]**
Bonus income for quality/efficiency (0-2)	-0.250 [-1.703,1.204]	-0.654 [-2.230,0.922]	-2.492 [-5.016,0.033]+	2.594 [-0.900,6.088]
Bonus income for IT	9.408 [5.140,13.675]**	11.799 [6.448,17.149]**	14.631 [7.705,21.557]**	6.724 [1.088,12.360]*
Physicians per 1000 persons	0.297 [-0.504,1.097]	-0.044 [-0.984,0.896]	-0.322 [-1.443,0.798]	0.397 [-0.674,1.469]
Number of hospitals	-0.095 [-0.190,-0.001]*	-0.092 [-0.204,0.021]	-0.148 [-0.312,0.017]+	0.025 [-0.037,0.086]
HMO penetration rate	-0.066 [-0.282,0.151]	-0.157 [-0.439,0.125]	-0.106 [-0.395,0.184]	-0.247 [-0.636,0.141]
Non-metropolitan area	3.220 [-0.902,7.342]	4.672 [-1.111,10.455]	5.952 [-2.754,14.657]	2.295 [-3.281,7.871]
Constant	22.457 [16.916,27.999]**	18.525 [12.082,24.968]**	25.492 [18.539,32.444]**	6.252 [-3.520,16.023]
N	1736	1736	1736	1736
R-squared	0.174	0.17	0.128	0.163
Adjusted r-squared	0.164	0.16	0.117	0.152

Notes: +p<0.10; *p<0.05; **p<0.01. Standard errors were adjusted to reflect the complex sampling frame of the National Survey of Small and Medium Sized Physician Practices. Data source: National Study of Small and Medium-sized Physician Practices (July 2007 - March 2009).

Table D1b: Effect of organizational characteristics and external factors on the adoption of HIT by 2008, small and medium-sized physician practices, results from cross-sectional linear regression

	Externally oriented HIT index	Interoperability index
Practice size, log	2.897 [1.180,4.615]**	6.000 [1.964,10.035]**
Specialty mix: Multispecialty (ref: prim. care)	-0.707 [-5.345,3.930]	-1.091 [-15.638,13.457]
Specialty mix: Specialty (ref: prim. care)	2.469 [-0.434,5.372]+	6.485 [1.432,11.538]*
Minority patients, %	0.033 [-0.019,0.085]	0.069 [0.009,0.129]*
Patient-centered management index (0-5)	0.388 [-0.013,0.789]+	0.519 [-0.280,1.319]
Participated in QI program	0.897 [-1.381,3.176]	-0.608 [-5.171,3.954]
Used plan-do-study-act	5.293 [1.337,9.250]*	5.155 [-0.493,10.804]+
Revenue: Medicare (ref: commercial)	0.035 [-0.039,0.110]	0.166 [0.006,0.327]*
Revenue: Medicaid (ref: commercial)	-0.088 [-0.188,0.013]+	-0.093 [-0.283,0.097]
Revenue: Uninsured (ref: commercial)	-0.071 [-0.171,0.029]	-0.159 [-0.343,0.026]+
Revenue: Other (ref: commercial)	-0.086 [-0.222,0.051]	-0.249 [-0.518,0.019]+
Ownership: Hospital/system/HMO (ref: phys.)	9.072 [4.750,13.395]**	12.147 [7.132,17.163]**
Ownership: Other (ref: physician owned)	-2.761 [-8.774,3.253]	-5.072 [-15.970,5.825]
Received patients from an IPA/PHO	3.053 [1.431,4.676]**	5.648 [2.716,8.580]**
Public reporting index (0-2)	1.467 [0.136,2.798]*	2.116 [0.174,4.057]*
Bonus income for quality/efficiency (0-2)	0.404 [-1.928,2.736]	1.442 [-1.365,4.250]
Bonus income for IT	5.606 [1.722,9.490]**	2.993 [-2.225,8.211]
Physicians per 1000 persons	0.817 [0.082,1.551]*	0.864 [-0.372,2.099]
Number of hospitals	-0.103 [-0.179,-0.027]*	-0.108 [-0.239,0.023]+
HMO penetration rate	0.080 [-0.142,0.303]	0.018 [-0.415,0.451]
Non-metropolitan area	0.916 [-2.368,4.201]	-2.626 [-10.487,5.235]
Constant	28.336 [19.659,37.013]**	56.412 [37.291,75.532]**
N	1736	1736
R-squared	0.12	0.114
Adjusted r-squared	0.109	0.103

Notes: +p<0.10; *p<0.05; **p<0.01. Standard errors were adjusted to reflect the complex sampling frame of the National Survey of Small and Medium Sized Physician Practices. Data source: National Study of Small and Medium-sized Physician Practices (July 2007 - March 2009).

Table D1c: Effect of organizational characteristics and external factors on the adoption of HIT by 2008, small and medium-sized physician practices, results from cross-sectional linear regression

	Electronic prescribing	EHR connects to EHR at main hospital	Email	Access EHR online
Practice size, log	6.923 [3.743,10.104]**	3.256 [1.464,5.047]**	-8.913 [-11.692,-6.133]**	1.017 [-0.175,2.209]+
Specialty mix: Multispecialty (ref: prim. care)	-0.244 [-15.245,14.758]	-2.777 [-11.957,6.403]	1.957 [-8.766,12.679]	-0.616 [-5.924,4.692]
Specialty mix: Specialty (ref: prim. care)	-2.371 [-7.308,2.566]	-0.480 [-3.577,2.618]	1.873 [-2.048,5.794]	-1.196 [-2.399,0.007]+
Minority patients, %	0.024 [-0.079,0.128]	0.023 [-0.082,0.128]	-0.030 [-0.087,0.027]	0.006 [-0.023,0.035]
Patient-centered management index (0-5)	0.645 [-0.783,2.072]	0.461 [-0.132,1.054]	0.102 [-0.933,1.137]	-0.052 [-0.447,0.344]
Participated in QI program	3.544 [-2.327,9.415]	1.635 [-2.655,5.925]	0.989 [-3.030,5.009]	1.939 [0.392,3.486]*
Used plan-do-study-act	6.312 [-3.045,15.669]	7.065 [1.092,13.039]*	8.446 [2.310,14.581]*	-0.235 [-3.673,3.204]
Revenue: Medicare (ref: commercial)	-0.123 [-0.284,0.037]	0.011 [-0.042,0.065]	-0.107 [-0.220,0.005]+	-0.031 [-0.084,0.022]
Revenue: Medicaid (ref: commercial)	-0.261 [-0.525,0.004]+	0.105 [-0.053,0.263]	-0.148 [-0.305,0.009]+	-0.031 [-0.111,0.050]
Revenue: Uninsured (ref: commercial)	-0.137 [-0.294,0.020]+	-0.034 [-0.129,0.060]	0.149 [-0.084,0.381]	-0.002 [-0.095,0.091]
Revenue: Other (ref: commercial)	0.002 [-0.204,0.207]	0.249 [0.048,0.450]*	-0.074 [-0.193,0.044]	-0.027 [-0.073,0.018]
Ownership: Hospital/system/HMO (ref: phys.)	2.418 [-7.348,12.185]	17.489 [6.540,28.437]**	2.849 [-2.526,8.224]	4.309 [0.328,8.289]*
Ownership: Other (ref: physician owned)	2.690 [-14.652,20.033]	-3.772 [-12.335,4.791]	-0.520 [-7.860,6.820]	-2.506 [-6.485,1.473]
Received patients from an IPA/PHO	0.212 [-5.695,6.119]	5.946 [1.983,9.909]**	-2.070 [-5.663,1.523]	0.340 [-1.284,1.965]
Public reporting index (0-2)	0.159 [-2.656,2.974]	2.178 [0.561,3.795]*	0.655 [-2.212,3.522]	0.931 [0.197,1.666]*
Bonus income for quality/efficiency (0-2)	2.341 [-3.610,8.293]	-2.449 [-5.386,0.489]+	-0.724 [-4.033,2.585]	-0.669 [-1.899,0.561]
Bonus income for IT	19.981 [9.973,29.989]**	6.238 [-0.401,12.877]+	3.898 [-1.167,8.963]	0.147 [-2.109,2.404]
Physicians per 1000 persons	0.566 [-0.766,1.897]	0.337 [-0.429,1.103]	2.214 [0.466,3.962]*	0.009 [-0.501,0.520]
Number of hospitals	-0.221 [-0.299,-0.143]**	-0.053 [-0.143,0.037]	-0.103 [-0.160,-0.047]**	-0.023 [-0.078,0.032]
HMO penetration rate	0.164 [-0.249,0.576]	0.230 [0.087,0.372]**	0.060 [-0.254,0.374]	0.056 [-0.043,0.155]
Non-metropolitan area	10.640 [0.324,20.957]*	6.428 [1.017,11.839]*	-1.313 [-4.592,1.966]	-1.463 [-3.338,0.412]
Constant	19.056 [7.440,30.672]**	-8.766 [-15.067,-2.464]**	17.705 [6.090,29.320]**	1.122 [-1.771,4.015]
N	1736	1736	1736	1736
R-squared	0.077	0.112	0.075	0.028
Adjusted r-squared	0.066	0.101	0.064	0.016

Notes: +p<0.10; *p<0.05; **p<0.01. Standard errors were adjusted to reflect the complex sampling frame of the National Survey of Small and Medium Sized Physician Practices. Data source: National Study of Small and Medium-sized Physician Practices (July 2007 - March 2009).

D.2. Small and medium-sized physician practices: adoption between 2008 and 2012

Table D2a: Effect of organizational characteristics and external factors on the change in adoption of HIT from 2008-2012, small and medium-sized physician practices, results from linear regression with organiztional fixed effects

	Overall HIT index	Internally oriented HIT index	Electronic health record index	Registries index
Yr12	6.118 [-3.733,15.969]	3.305 [-10.193,16.803]	2.343 [-14.373,19.059]	3.018 [-12.861,18.898]
Practice size, log	-2.597 [-5.620,0.426]+	-2.589 [-6.563,1.386]	-4.131 [-8.988,0.726]+	-0.154 [-5.396,5.088]
Specialty mix: Multispecialty (ref: prim. care)	-12.822 [-23.550,-2.093]*	-16.949 [-29.994,-3.904]*	-22.764 [-41.877,-3.650]*	-6.354 [-18.643,5.935]
Specialty mix: Specialty (ref: prim. care)	-1.800 [-17.282,13.682]	-4.549 [-23.896,14.798]	-0.010 [-23.529,23.510]	-11.363 [-27.606,4.880]
Minority patients, %	0.133 [-0.000,0.266]+	0.147 [-0.034,0.328]	0.164 [-0.064,0.393]	0.080 [-0.147,0.306]
Patient-centered management index (0-5)	0.257 [-0.819,1.333]	0.541 [-0.945,2.027]	0.718 [-1.125,2.560]	0.268 [-1.564,2.100]
Participated in QI program	-1.444 [-6.792,3.903]	0.292 [-6.890,7.474]	-3.063 [-12.187,6.061]	5.822 [-3.322,14.965]
Used plan-do-study-act	5.627 [-0.753,12.008]+	5.580 [-3.254,14.413]	8.530 [-2.515,19.576]	0.535 [-9.577,10.647]
Revenue: Medicare (ref: commercial)	-0.067 [-0.217,0.083]	-0.069 [-0.273,0.135]	-0.258 [-0.501,-0.015]*	0.242 [-0.000,0.483]+
Revenue: Medicaid (ref: commercial)	-0.105 [-0.360,0.150]	-0.107 [-0.447,0.234]	-0.232 [-0.659,0.195]	0.135 [-0.320,0.591]
Revenue: Uninsured (ref: commercial)	0.023 [-0.137,0.184]	0.023 [-0.189,0.236]	-0.063 [-0.339,0.213]	0.208 [-0.088,0.504]
Revenue: Other (ref: commercial)	0.129 [-0.051,0.308]	0.154 [-0.087,0.395]	-0.023 [-0.315,0.268]	0.465 [0.151,0.779]**
Ownership: Hospital/system/HMO (ref: phys.)	-7.885 [-16.394,0.623]+	-10.749 [-22.112,0.614]+	-10.544 [-25.348,4.260]	-10.150 [-23.279,2.978]
Ownership: Other (ref: physician owned)	-10.830 [-21.990,0.330]+	-13.653 [-28.237,0.932]+	-14.042 [-33.032,4.949]	-12.494 [-30.882,5.893]
Received patients from an IPA/PHO	2.398 [-1.853,6.649]	1.848 [-3.859,7.554]	-1.332 [-8.677,6.012]	8.062 [1.586,14.537]*
Public reporting index (0-2)	1.961 [-0.303,4.226]+	2.007 [-1.033,5.047]	0.631 [-3.179,4.441]	4.239 [0.457,8.022]*
Bonus income for quality/efficiency (0-2)	-1.032 [-3.887,1.823]	-0.904 [-4.794,2.986]	-2.584 [-7.493,2.325]	2.402 [-2.289,7.094]
Bonus income for IT	4.215 [-1.022,9.451]	4.420 [-2.681,11.521]	6.050 [-2.764,14.864]	2.194 [-7.167,11.556]
Yr12*Practice size, log	3.046 [0.752,5.340]**	3.269 [0.194,6.345]*	4.712 [0.755,8.670]*	1.052 [-2.570,4.675]
Yr12*Specialty mix: Multispec. (ref: prim. care)	2.444 [-9.398,14.285]	3.387 [-10.887,17.660]	13.856 [-7.675,35.388]	-15.565 [-28.857,-2.272]*
Yr12*Specialty mix: Specialty (ref: prim. care)	-1.154 [-6.230,3.921]	-0.381 [-7.573,6.811]	-1.311 [-10.542,7.920]	-5.382 [-12.722,1.958]
Yr12*Minority patients, %	0.018 [-0.076,0.113]	0.059 [-0.070,0.188]	0.073 [-0.097,0.242]	0.032 [-0.120,0.184]
Yr12*Patient-centered management index (0-5)	1.541 [0.168,2.914]*	1.977 [0.086,3.869]*	2.396 [0.011,4.781]*	1.177 [-0.954,3.308]
Yr12*Participated in QI program	8.155 [0.980,15.330]*	8.763 [-0.650,18.177]+	15.151 [3.127,27.176]*	-2.644 [-15.833,10.545]
Yr12*Used plan-do-study-act	-9.401 [-17.510,-1.291]*	-9.911 [-20.962,1.139]+	-16.173 [-30.232,-2.113]*	0.433 [-13.006,13.871]
Yr12*Revenue: Medicare (ref: commercial)	0.125 [0.005,0.244]*	0.195 [0.031,0.358]*	0.354 [0.154,0.555]**	-0.063 [-0.264,0.138]
Yr12*Revenue: Medicaid (ref: commercial)	0.017 [-0.178,0.212]	0.018 [-0.241,0.277]	0.087 [-0.261,0.436]	-0.082 [-0.406,0.242]
Yr12*Revenue: Uninsured (ref: commercial)	-0.157 [-0.295,-0.020]*	-0.111 [-0.294,0.072]	-0.045 [-0.292,0.202]	-0.236 [-0.457,-0.014]*
Yr12*Revenue: Other (ref: commercial)	-0.015 [-0.253,0.223]	0.030 [-0.274,0.335]	0.289 [-0.106,0.684]	-0.423 [-0.764,-0.081]*
Yr12*Ownership: Hosp./system/HMO (ref: phys.)	9.322 [1.929,16.715]*	12.903 [2.935,22.872]*	13.328 [0.494,26.162]*	12.752 [0.766,24.739]*
Yr12*Ownership: Other (ref: physician owned)	11.452 [0.280,22.624]*	16.708 [1.993,31.422]*	16.152 [-3.680,35.984]	18.201 [0.862,35.540]*
Yr12*Received patients from an IPA/PHO	2.812 [-2.608,8.232]	6.316 [-0.890,13.523]+	5.628 [-3.930,15.185]	7.339 [-1.648,16.326]
Yr12*Public reporting index (0-2)	-1.610 [-4.564,1.343]	-2.077 [-6.026,1.873]	-1.573 [-6.438,3.291]	-2.605 [-7.460,2.251]
Yr12*Bonus income for quality/efficiency (0-2)	4.383 [1.094,7.671]**	5.991 [1.675,10.306]**	6.369 [0.500,12.239]*	5.202 [-0.022,10.425]+
Yr12*Bonus income for IT	-0.501 [-7.189,6.188]	1.672 [-7.302,10.645]	-4.124 [-15.555,7.308]	10.936 [-0.371,22.243]+
Yr12*Physicians per 1000 persons	-0.585 [-1.586,0.415]	-0.917 [-2.228,0.394]	-0.673 [-2.397,1.052]	-1.335 [-2.794,0.125]+
Yr12*Number of hospitals	0.101 [-0.051,0.253]	0.132 [-0.058,0.321]	0.173 [-0.047,0.393]	0.073 [-0.127,0.274]
Yr12*HMO penetration rate	0.000 [-0.213,0.214]	-0.004 [-0.296,0.288]	-0.125 [-0.486,0.236]	0.247 [-0.079,0.574]
Yr12*Non-metropolitan area	3.956 [-1.628,9.541]	5.007 [-2.410,12.424]	5.970 [-3.758,15.698]	3.684 [-4.966,12.335]
Constant	29.852 [20.660,39.043]**	22.259 [9.641,34.876]**	37.981 [23.393,52.569]**	-4.688 [-20.687,11.311]
N	1440	1440	1440	1440
R-squared (within)	0.481	0.447	0.452	0.199
Adjusted r-squared (within)	0.467	0.432	0.436	0.176

Notes: +p<0.10; *p<0.05; **p<0.01. Standard errors were clustered by physician organization to account for non-independence between the same organization over time. Data source: The cohort of physician practices responding to both the National Study of Small and Medium-sized Physician Practices (July 2007 - March 2009) and the National Study of Physician Organizations III (January 2012 – ongoing; data from responses up to March 2013).

Table D2b: Effect of organizational characteristics and external factors on the change in adoption of HIT from 2008-2012, small and medium-sized physician practices, results from linear regression with organiztional fixed effects

	Externally oriented HIT index	Interoperability index
Yr12	11.018 [0.471,21.565]*	7.589 [-10.300,25.479]
Practice size, log	-2.553 [-5.480,0.375]+	-1.364 [-5.793,3.066]
Specialty mix: Multispecialty (ref: prim. care)	-6.395 [-17.292,4.503]	-8.537 [-26.484,9.410]
Specialty mix: Specialty (ref: prim. care)	1.782 [-11.413,14.978]	-7.833 [-25.521,9.856]
Minority patients, %	0.116 [-0.008,0.240]+	0.082 [-0.120,0.285]
Patient-centered management index (0-5)	-0.175 [-1.146,0.796]	-0.291 [-1.897,1.314]
Participated in QI program	-4.049 [-9.107,1.009]	-8.510 [-17.472,0.451]+
Used plan-do-study-act	5.653 [-0.106,11.411]+	8.983 [0.661,17.305]*
Revenue: Medicare (ref: commercial)	-0.059 [-0.197,0.079]	-0.043 [-0.259,0.173]
Revenue: Medicaid (ref: commercial)	-0.102 [-0.333,0.130]	-0.040 [-0.414,0.333]
Revenue: Uninsured (ref: commercial)	0.026 [-0.151,0.203]	0.024 [-0.296,0.344]
Revenue: Other (ref: commercial)	0.090 [-0.119,0.299]	0.077 [-0.294,0.448]
Ownership: Hospital/system/HMO (ref: phys.)	-3.458 [-10.818,3.903]	-3.540 [-14.222,7.143]
Ownership: Other (ref: physician owned)	-6.457 [-17.574,4.661]	-18.872 [-37.900,0.157]+
Received patients from an IPA/PHO	3.200 [-0.786,7.186]	2.462 [-3.996,8.920]
Public reporting index (0-2)	1.919 [-0.249,4.087]+	2.209 [-1.437,5.854]
Bonus income for quality/efficiency (0-2)	-1.232 [-4.054,1.591]	-3.167 [-7.923,1.590]
Bonus income for IT	3.740 [-1.133,8.614]	2.984 [-4.731,10.699]
Yr12*Practice size, log	2.623 [0.320,4.925]*	1.111 [-2.632,4.855]
Yr12*Specialty mix: Multispec. (ref: prim. care)	0.929 [-10.655,12.513]	5.658 [-13.355,24.671]
Yr12*Specialty mix: Specialty (ref: prim. care)	-1.618 [-6.463,3.227]	-2.336 [-9.728,5.057]
Yr12*Minority patients, %	-0.046 [-0.129,0.038]	-0.043 [-0.181,0.095]
Yr12*Patient-centered management index (0-5)	0.850 [-0.491,2.192]	1.337 [-0.917,3.591]
Yr12*Participated in QI program	7.153 [0.403,13.903]*	9.968 [-1.040,20.977]+
Yr12*Used plan-do-study-act	-8.595 [-15.370,-1.820]*	-11.151 [-20.370,-1.933]*
Yr12*Revenue: Medicare (ref: commercial)	0.012 [-0.108,0.132]	-0.093 [-0.291,0.106]
Yr12*Revenue: Medicaid (ref: commercial)	0.014 [-0.163,0.191]	0.003 [-0.295,0.301]
Yr12*Revenue: Uninsured (ref: commercial)	-0.231 [-0.398,-0.064]**	-0.407 [-0.713,-0.100]**
Yr12*Revenue: Other (ref: commercial)	-0.086 [-0.330,0.159]	-0.041 [-0.442,0.359]
Yr12*Ownership: Hosp./system/HMO (ref: phys.)	3.676 [-2.631,9.983]	1.101 [-7.694,9.897]
Yr12*Ownership: Other (ref: physician owned)	3.266 [-8.439,14.971]	14.526 [-5.833,34.884]
Yr12*Received patients from an IPA/PHO	-2.799 [-8.057,2.460]	-3.198 [-11.420,5.023]
Yr12*Public reporting index (0-2)	-0.919 [-3.634,1.796]	-1.396 [-5.637,2.844]
Yr12*Bonus income for quality/efficiency (0-2)	1.835 [-1.319,4.989]	1.012 [-4.336,6.361]
Yr12*Bonus income for IT	-3.844 [-10.056,2.368]	-4.368 [-14.348,5.611]
Yr12*Physicians per 1000 persons	-0.085 [-1.059,0.888]	-0.449 [-2.212,1.315]
Yr12*Number of hospitals	0.056 [-0.082,0.194]	-0.021 [-0.251,0.210]
Yr12*HMO penetration rate	-0.002 [-0.204,0.201]	0.118 [-0.228,0.463]
Yr12*Non-metropolitan area	2.238 [-3.439,7.915]	4.542 [-5.572,14.656]
Constant	41.251 [32.743,49.759]**	80.844 [66.927,94.761]**
N	1440	1440
R-squared (within)	0.285	0.053
Adjusted r-squared (within)	0.265	0.026

Notes: +p<0.10; *p<0.05; **p<0.01. Standard errors were clustered by physician organization to account for non-independence between the same organization over time. Data source: The cohort of physician practices responding to both the National Study of Small and Medium-sized Physician Practices (July 2007 - March 2009) and the National Study of Physician Organizations III (January 2012 – ongoing; data from responses up to March 2013).

Table D2c: Effect of organizational characteristics and external factors on the change in adoption of HIT from 2008-2012, small and medium-sized physician practices, results from linear regression with organiztional fixed effects

	Electronic prescribing	EHR connects to EHR of main hospital	Email	Access EHR online
Yr12	37.015 [15.320,58.709]**	1.759 [-13.927,17.445]	4.931 [-12.733,22.595]	10.656 [-6.978,28.290]
Practice size, log	-1.116 [-7.467,5.234]	-3.678 [-9.550,2.193]	-9.898 [-15.623,-4.173]*	0.915 [-4.526,6.355]
Specialty mix: Multispecialty (ref: prim. care)	-13.553 [-34.921,7.815]	-4.459 [-19.184,10.266]	4.177 [-6.378,14.732]	-5.316 [-24.281,13.648]
Specialty mix: Specialty (ref: prim. care)	0.752 [-25.555,27.060]	2.848 [-22.938,28.634]	21.414 [1.973,40.854]*	10.962 [-10.674,32.597]
Minority patients, %	0.388 [0.106,0.670]**	0.119 [-0.105,0.342]	0.031 [-0.207,0.268]	0.030 [-0.195,0.255]
Patient-centered management index (0-5)	1.537 [-0.868,3.942]	-0.863 [-2.752,1.026]	-0.092 [-1.974,1.790]	-0.930 [-2.773,0.912]
Participated in QI program	2.835 [-7.455,13.125]	3.635 [-6.398,13.667]	-7.146 [-15.477,1.185]+	-2.135 [-11.256,6.986]
Used plan-do-study-act	7.302 [-5.752,20.356]	7.616 [-5.511,20.744]	6.470 [-4.594,17.534]	-8.767 [-19.523,1.990]
Revenue: Medicare (ref: commercial)	-0.274 [-0.594,0.046]+	-0.126 [-0.353,0.101]	0.083 [-0.145,0.310]	0.032 [-0.206,0.270]
Revenue: Medicaid (ref: commercial)	-0.539 [-1.073,-0.004]*	0.091 [-0.382,0.565]	-0.063 [-0.477,0.351]	-0.079 [-0.482,0.323]
Revenue: Uninsured (ref: commercial)	-0.203 [-0.590,0.184]	0.122 [-0.096,0.340]	0.185 [-0.096,0.467]	0.006 [-0.281,0.294]
Revenue: Other (ref: commercial)	-0.062 [-0.479,0.355]	-0.062 [-0.432,0.308]	0.309 [-0.012,0.630]+	0.213 [-0.036,0.461]+
Ownership: Hospital/system/HMO (ref: phys.)	-8.263 [-25.213,8.688]	-4.469 [-20.718,11.780]	0.524 [-12.757,13.805]	-1.377 [-14.578,11.824]
Ownership: Other (ref: physician owned)	-12.621 [-36.601,11.360]	-4.802 [-25.304,15.700]	15.323 [1.478,29.168]*	13.519 [-9.126,36.164]
Received patients from an IPA/PHO	0.584 [-8.396,9.563]	7.484 [0.414,14.554]*	4.438 [-2.340,11.217]	2.509 [-4.939,9.956]
Public reporting index (0-2)	-0.520 [-5.225,4.185]	4.788 [1.129,8.446]*	1.046 [-2.993,5.084]	1.493 [-2.508,5.495]
Bonus income for quality/efficiency (0-2)	2.737 [-3.196,8.670]	-2.299 [-7.049,2.451]	-1.444 [-6.809,3.922]	1.882 [-2.947,6.711]
Bonus income for IT	17.603 [6.930,28.275]**	9.259 [-0.313,18.830]+	-1.703 [-11.235,7.829]	-7.927 [-17.245,1.391]+
Yr12*Practice size, log	0.303 [-4.826,5.431]	3.949 [-0.287,8.184]+	5.458 [1.587,9.328]**	5.317 [1.340,9.294]**
Yr12*Specialty mix: Multispec. (ref: prim. care)	-0.052 [-24.191,24.087]	-4.986 [-22.381,12.409]	-3.359 [-14.242,7.524]	-2.076 [-24.876,20.725]
Yr12*Specialty mix: Specialty (ref: prim. care)	4.390 [-6.982,15.763]	1.085 [-7.293,9.464]	-6.442 [-14.591,1.707]	-3.355 [-11.914,5.205]
Yr12*Minority patients, %	-0.172 [-0.378,0.033]	-0.093 [-0.244,0.057]	0.093 [-0.045,0.231]	-0.019 [-0.174,0.135]
Yr12*Patient-centered management index (0-5)	-0.610 [-3.497,2.278]	0.932 [-1.368,3.233]	0.826 [-1.466,3.118]	0.790 [-1.540,3.121]
Yr12*Participated in QI program	5.387 [-8.603,19.377]	1.783 [-12.088,15.654]	10.517 [-1.071,22.106]+	2.479 [-9.661,14.619]
Yr12*Used plan-do-study-act	-16.726 [-33.889,0.436]+	-15.072 [-30.239,0.094]+	-6.975 [-19.564,5.615]	12.065 [-1.487,25.617]+
Yr12*Revenue: Medicare (ref: commercial)	0.439 [0.174,0.704]**	0.054 [-0.136,0.244]	-0.060 [-0.276,0.156]	-0.070 [-0.276,0.137]
Yr12*Revenue: Medicaid (ref: commercial)	0.479 [0.029,0.930]*	-0.105 [-0.446,0.236]	-0.219 [-0.529,0.091]	-0.069 [-0.402,0.265]
Yr12*Revenue: Uninsured (ref: commercial)	-0.216 [-0.550,0.119]	-0.189 [-0.398,0.020]+	0.214 [-0.082,0.510]	-0.204 [-0.421,0.013]+
Yr12*Revenue: Other (ref: commercial)	0.210 [-0.307,0.727]	0.063 [-0.297,0.423]	-0.390 [-0.804,0.025]+	-0.359 [-0.669,-0.049]*
Yr12*Ownership: Hosp./system/HMO (ref: phys.)	4.744 [-10.856,20.345]	20.057 [4.887,35.226]**	0.022 [-12.336,12.380]	-2.395 [-13.786,8.996]
Yr12*Ownership: Other (ref: physician owned)	3.865 [-21.754,29.484]	5.729 [-14.328,25.787]	-16.202 [-33.037,0.633]+	-14.107 [-34.560,6.346]
Yr12*Received patients from an IPA/PHO	5.847 [-5.597,17.291]	-6.395 [-16.416,3.625]	-4.408 [-13.628,4.812]	-5.038 [-14.775,4.699]
Yr12*Public reporting index (0-2)	3.188 [-2.839,9.214]	-3.016 [-8.096,2.064]	-0.854 [-6.124,4.416]	-1.564 [-6.575,3.447]
Yr12*Bonus income for quality/efficiency (0-2)	2.644 [-4.194,9.481]	2.316 [-3.135,7.768]	4.391 [-1.251,10.032]	0.458 [-5.218,6.134]
Yr12*Bonus income for IT	-18.924 [-32.201,-5.647]**	-5.446 [-17.062,6.170]	0.840 [-10.902,12.583]	9.724 [-1.372,20.820]+
Yr12*Physicians per 1000 persons	-0.798 [-2.953,1.356]	0.181 [-1.379,1.741]	0.260 [-1.683,2.203]	1.104 [-0.630,2.839]
Yr12*Number of hospitals	0.092 [-0.166,0.350]	0.190 [-0.015,0.395]+	-0.058 [-0.202,0.087]	0.227 [-0.009,0.463]+
Yr12*HMO penetration rate	-0.186 [-0.635,0.263]	0.010 [-0.341,0.361]	-0.208 [-0.529,0.113]	0.019 [-0.344,0.382]
Yr12*Non-metropolitan area	-5.320 [-17.904,7.264]	4.468 [-4.112,13.047]	-1.895 [-10.002,6.212]	4.789 [-4.840,14.419]
Constant	31.357 [12.638,50.076]**	7.107 [-7.813,22.027]	10.347 [-5.214,25.907]	-2.585 [-17.044,11.874]
N	1440	1440	1440	1440
R-squared (within)	0.493	0.115	0.09	0.233
Adjusted r-squared (within)	0.479	0.091	0.065	0.212

Notes: +p<0.10; *p<0.05; **p<0.01. Standard errors were clustered by physician organization to account for non-independence between the same organization over time. Data source: The cohort of physician practices responding to both the National Study of Small and Medium-sized Physician Practices (July 2007 - March 2009) and the National Study of Physician Organizations III (January 2012 – ongoing; data from responses up to March 2013).

D.3. Large medical groups: adoption by 2006

Table D3a: Effect of organizational characteristics and external factors on the adoption of HIT by 2006, large medical groups, results from cross-sectional linear regression

	Overall HIT index	Internally oriented HIT index	Electronic health record index	Registries index
Practice size, log	8.830 [5.663,11.997]**	8.564 [4.830,12.298]**	10.429 [5.721,15.138]**	5.514 [1.067,9.962]*
Specialty mix: Multispecialty (ref: prim. care)	9.284 [-2.950,21.517]	9.745 [-5.505,24.996]	0.080 [-18.551,18.710]	25.851 [4.640,47.061]*
Specialty mix: Specialty (ref: prim. care)	2.215 [-5.928,10.359]	1.999 [-7.734,11.731]	1.533 [-10.492,13.559]	3.236 [-8.274,14.745]
Patient-centered management index (0-5)	1.372 [-0.720,3.464]	1.694 [-0.764,4.152]	1.117 [-1.809,4.043]	3.056 [-0.072,6.185]+
Participated in QI program	4.368 [-2.251,10.987]	4.600 [-3.272,12.473]	6.418 [-3.271,16.106]	0.928 [-8.722,10.577]
Revenue: Medicare (ref: commercial)	0.100 [-0.106,0.306]	0.178 [-0.062,0.419]	0.364 [0.049,0.678]*	-0.140 [-0.454,0.173]
Revenue: Medicaid (ref: commercial)	-0.122 [-0.371,0.126]	-0.090 [-0.381,0.201]	-0.106 [-0.459,0.247]	-0.055 [-0.358,0.248]
Revenue: Uninsured (ref: commercial)	0.218 [-0.174,0.610]	0.268 [-0.202,0.738]	0.431 [-0.185,1.046]	-0.071 [-0.620,0.478]
Revenue: Other (ref: commercial)	-0.247 [-0.587,0.094]	-0.306 [-0.734,0.123]	-0.292 [-0.795,0.211]	-0.284 [-0.800,0.233]
Ownership: Hospital/system/HMO (ref: phys.)	0.090 [-8.127,8.306]	0.232 [-9.545,10.008]	-1.230 [-13.357,10.898]	5.419 [-6.149,16.987]
Ownership: Other (ref: physician owned)	1.328 [-10.532,13.188]	1.394 [-12.118,14.906]	-6.925 [-21.924,8.074]	17.502 [1.601,33.404]*
Received patients from an IPA/PHO	2.640 [-3.793,9.074]	2.876 [-5.078,10.831]	1.249 [-8.218,10.716]	3.558 [-5.919,13.034]
Bonus income for quality/efficiency (0-2)	-0.444 [-4.822,3.935]	1.092 [-4.160,6.344]	-2.695 [-9.227,3.836]	8.003 [1.715,14.291]*
Bonus income for IT	13.088 [4.707,21.469]**	14.664 [4.943,24.385]**	15.403 [2.954,27.852]*	11.476 [-1.077,24.029]+
Physicians per 1000 persons	1.211 [0.260,2.162]*	1.160 [-0.020,2.340]+	1.958 [0.452,3.463]*	-0.371 [-1.935,1.193]
Number of hospitals	-0.039 [-0.155,0.077]	-0.046 [-0.186,0.094]	-0.082 [-0.254,0.091]	0.028 [-0.142,0.198]
HMO penetration rate	-0.246 [-0.492,-0.001]*	-0.252 [-0.543,0.039]+	-0.414 [-0.771,-0.057]*	0.022 [-0.344,0.389]
Non-metropolitan area	-12.566 [-22.313,-2.819]*	-15.797 [-27.111,-4.483]**	-20.145 [-35.172,-5.117]**	-8.460 [-21.999,5.078]
Constant	-3.014 [-18.987,12.959]	-6.233 [-25.718,13.253]	-8.650 [-33.479,16.180]	-2.764 [-27.485,21.957]
N	321	321	321	321
R-squared	0.251	0.21	0.195	0.168
Adjustd r-squared	0.206	0.163	0.147	0.118

Notes: +p<0.10; *p<0.05; **p<0.01. N=321. Robust standard errors were used to account for heterogeneity. Data source: National Study of Physician Organizations II (March 2006 - March 2007).

Table D3b: Effect of organizational characteristics and external factors on the adoption of HIT by 2006, large medical groups, results from cross-sectional linear regression

	Externally oriented HIT index	Interoperability index
Practice size, log	9.241 [5.995,12.486]**	9.646 [5.208,14.084]**
Specialty mix: Multispecialty (ref: prim. care)	8.691 [-3.157,20.538]	14.363 [-4.079,32.806]
Specialty mix: Specialty (ref: prim. care)	2.485 [-5.960,10.929]	1.465 [-11.179,14.109]
Patient-centered management index (0-5)	0.828 [-1.270,2.926]	0.409 [-2.563,3.381]
Participated in QI program	4.076 [-2.479,10.631]	5.758 [-4.064,15.579]
Revenue: Medicare (ref: commercial)	-0.019 [-0.230,0.192]	-0.014 [-0.330,0.302]
Revenue: Medicaid (ref: commercial)	-0.174 [-0.401,0.053]	-0.142 [-0.485,0.201]
Revenue: Uninsured (ref: commercial)	0.138 [-0.251,0.526]	0.156 [-0.450,0.763]
Revenue: Other (ref: commercial)	-0.152 [-0.496,0.192]	-0.064 [-0.554,0.425]
Ownership: Hospital/system/HMO (ref: phys.)	-0.052 [-8.257,8.153]	-2.931 [-14.481,8.618]
Ownership: Other (ref: physician owned)	1.289 [-10.287,12.865]	-1.481 [-16.540,13.579]
Received patients from an IPA/PHO	1.988 [-4.392,8.369]	0.372 [-8.951,9.696]
Bonus income for quality/efficiency (0-2)	-2.675 [-7.164,1.814]	-3.870 [-10.498,2.758]
Bonus income for IT	10.573 [1.465,19.681]*	13.539 [1.288,25.789]*
Physicians per 1000 persons	1.309 [0.411,2.208]**	1.384 [0.146,2.623]*
Number of hospitals	-0.029 [-0.138,0.081]	-0.069 [-0.239,0.100]
HMO penetration rate	-0.237 [-0.482,0.008]+	-0.286 [-0.647,0.075]
Non-metropolitan area	-7.523 [-18.882,3.837]	-11.724 [-29.199,5.751]
Constant	1.929 [-13.615,17.474]	22.452 [-0.277,45.181]+
N	321	321
R-squared	0.228	0.136
Adjustd r-squared	0.182	0.084

Notes: +p<0.10; *p<0.05; **p<0.01. N=321. Robust standard errors were used to account for heterogeneity. Data source: National Study of Physician Organizations II (March 2006 - March 2007).

Table D3c: Effect of organizational characteristics and external factors on the adoption of HIT by 2006, large medical groups, results from cross-sectional linear regression

	Electronic prescribing	EHR connects to EHR at main hospital	Email	Access EHR online
Practice size, log	6.164 [0.338,11.989]*	13.362 [8.140,18.585]**	10.486 [4.633,16.340]**	5.733 [1.790,9.676]**
Specialty mix: Multispecialty (ref: prim. care)	0.741 [-21.825,23.306]	18.575 [-3.118,40.268]+	5.369 [-17.569,28.308]	-6.940 [-14.180,0.301]+
Specialty mix: Specialty (ref: prim. care)	7.123 [-7.481,21.726]	4.434 [-8.044,16.913]	-0.634 [-14.999,13.732]	2.074 [-4.317,8.465]
Patient-centered management index (0-5)	4.681 [0.857,8.504]*	-1.680 [-4.861,1.501]	-0.023 [-3.440,3.393]	1.593 [-0.498,3.684]
Participated in QI program	7.220 [-4.590,19.030]	-0.524 [-10.835,9.786]	4.217 [-7.555,15.988]	0.347 [-5.881,6.575]
Revenue: Medicare (ref: commercial)	-0.121 [-0.528,0.285]	-0.016 [-0.338,0.306]	0.027 [-0.359,0.413]	0.019 [-0.156,0.194]
Revenue: Medicaid (ref: commercial)	-0.376 [-0.722,-0.030]*	-0.218 [-0.505,0.068]	-0.168 [-0.564,0.227]	-0.027 [-0.191,0.137]
Revenue: Uninsured (ref: commercial)	-0.030 [-0.737,0.677]	0.195 [-0.377,0.766]	0.362 [-0.365,1.089]	-0.032 [-0.271,0.207]
Revenue: Other (ref: commercial)	-0.418 [-1.054,0.217]	-0.039 [-0.620,0.543]	-0.247 [-0.842,0.347]	-0.170 [-0.428,0.089]
Ownership: Hospital/system/HMO (ref: phys.)	-3.610 [-17.242,10.022]	4.484 [-9.645,18.614]	3.862 [-10.592,18.315]	3.696 [-4.967,12.359]
Ownership: Other (ref: physician owned)	-2.216 [-20.674,16.241]	16.693 [0.059,33.328]*	0.093 [-19.707,19.893]	-1.102 [-10.674,8.470]
Received patients from an IPA/PHO	4.738 [-6.888,16.363]	-0.415 [-11.000,10.170]	4.199 [-7.379,15.777]	4.277 [-1.932,10.485]
Bonus income for quality/efficiency (0-2)	-1.926 [-9.947,6.095]	-5.398 [-12.367,1.572]	0.853 [-6.988,8.695]	-0.645 [-4.916,3.626]
Bonus income for IT	5.669 [-10.597,21.936]	15.240 [1.248,29.231]*	4.365 [-11.072,19.803]	8.118 [-1.625,17.862]
Physicians per 1000 persons	0.364 [-1.665,2.392]	1.857 [0.219,3.496]*	1.811 [0.099,3.522]*	0.980 [-0.556,2.516]
Number of hospitals	-0.066 [-0.273,0.142]	-0.160 [-0.327,0.006]+	0.243 [0.041,0.446]*	-0.009 [-0.105,0.086]
HMO penetration rate	-0.210 [-0.644,0.223]	-0.301 [-0.696,0.093]	-0.117 [-0.532,0.298]	-0.173 [-0.428,0.082]
Non-metropolitan area	-13.921 [-34.116,6.275]	-2.879 [-19.405,13.646]	-0.594 [-18.841,17.652]	-0.094 [-9.404,9.216]
Constant	19.401 [-11.147,49.950]	-25.920 [-51.423,-0.418]*	-25.215 [-53.647,3.217]+	-22.117 [-39.907,-4.326]*
N	321	321	321	321
R-squared	0.101	0.196	0.126	0.156
Adjustd r-squared	0.048	0.148	0.073	0.106

Notes: +p<0.10; *p<0.05; **p<0.01. N=321. Robust standard errors were used to account for heterogeneity. Data source: National Study of Physician Organizations II (March 2006 - March 2007).

D.4. Large medical groups: adoption between 2008 and 2012

Table D4a: Effect of organizational characteristics and external factors on the change in the adoption of HIT from 2006-2012, large medical groups, results from linear regression with fixed organizational effects

	Overall HIT index	Internally oriented HIT index	Electronic health record index	Registries index
Yr12	41.732 [8.247,75.218]*	40.249 [-2.425,82.923]+	65.376 [10.983,119.768]*	-6.511 [-62.720,49.697]
Practice size, log	4.483 [-4.828,13.793]	2.103 [-8.848,13.054]	10.214 [-3.803,24.232]	-11.511 [-26.163,3.141]
Specialty mix: Multispecialty (ref: prim. care)	26.118 [-11.361,63.597]	46.403 [-0.399,93.204]+	20.503 [-39.087,80.092]	101.552 [52.380,150.724]**
Specialty mix: Specialty (ref: prim. care)	-2.751 [-19.891,14.389]	4.494 [-15.852,24.841]	-3.131 [-29.691,23.428]	18.431 [-4.335,41.197]
Patient-centered management index (0-5)	1.494 [-2.009,4.996]	0.487 [-4.105,5.078]	-1.263 [-7.331,4.805]	3.041 [-2.245,8.327]
Participated in QI program	0.184 [-13.414,13.783]	3.558 [-13.507,20.622]	2.398 [-19.910,24.705]	5.141 [-12.708,22.990]
Revenue: Medicare (ref: commercial)	-0.074 [-0.571,0.422]	0.182 [-0.396,0.759]	0.329 [-0.513,1.171]	-0.114 [-0.730,0.501]
Revenue: Medicaid (ref: commercial)	0.287 [-0.098,0.673]	0.325 [-0.142,0.791]	0.734 [-0.001,1.470]+	-0.392 [-0.941,0.158]
Revenue: Uninsured (ref: commercial)	0.033 [-0.522,0.589]	-0.269 [-1.066,0.528]	-0.068 [-1.128,0.991]	-0.668 [-1.812,0.476]
Revenue: Other (ref: commercial)	0.249 [-0.483,0.981]	0.051 [-0.852,0.953]	0.381 [-0.848,1.609]	-0.480 [-1.415,0.456]
Ownership: Hospital/system/HMO (ref: phys.)	-7.978 [-26.365,10.408]	-18.715 [-40.792,3.362]+	-30.928 [-61.006,-0.849]*	5.562 [-20.371,31.495]
Ownership: Other (ref: physician owned)	15.300 [-8.896,39.496]	15.550 [-14.586,45.687]	9.469 [-30.072,49.011]	31.544 [-8.007,71.094]
Received patients from an IPA/PHO	7.186 [-6.480,20.852]	12.480 [-6.426,31.386]	10.769 [-12.456,33.994]	14.221 [-4.934,33.377]
Bonus income for quality/efficiency (0-2)	0.339 [-8.868,9.546]	1.625 [-9.440,12.690]	-2.585 [-17.317,12.146]	10.088 [-2.447,22.624]
Bonus income for IT	-2.649 [-20.925,15.628]	-4.040 [-27.733,19.652]	-3.486 [-33.912,26.940]	-6.482 [-31.456,18.492]
Yr12*Practice size, log	-6.891 [-13.959,0.176]+	-6.775 [-16.215,2.665]	-11.225 [-23.357,0.908]+	0.301 [-10.531,11.134]
Yr12*Specialty mix: Multispec. (ref: prim. care)	-10.752 [-48.535,27.031]	-22.723 [-73.076,27.630]	-0.081 [-60.876,60.714]	-72.342 [-130.366,-14.317]*
Yr12*Specialty mix: Specialty (ref: prim. care)	20.461 [-16.036,56.957]	34.037 [-11.930,80.005]	37.852 [-21.083,96.786]	47.926 [-1.643,97.496]+
Yr12*Patient-centered management index (0-5)	-2.396 [-8.376,3.584]	-2.533 [-10.117,5.051]	0.063 [-10.337,10.463]	-7.233 [-14.619,0.154]+
Yr12*Participated in QI program	4.446 [-15.492,24.384]	4.244 [-22.255,30.743]	1.224 [-32.394,34.842]	9.619 [-16.278,35.516]
Yr12*Revenue: Medicare (ref: commercial)	0.080 [-0.436,0.596]	0.055 [-0.607,0.716]	-0.014 [-0.877,0.849]	0.227 [-0.483,0.937]
Yr12*Revenue: Medicaid (ref: commercial)	0.029 [-0.638,0.697]	0.191 [-0.601,0.984]	0.115 [-0.952,1.182]	0.289 [-0.629,1.207]
Yr12*Revenue: Uninsured (ref: commercial)	0.313 [-0.385,1.010]	0.524 [-0.389,1.437]	0.852 [-0.337,2.040]	0.057 [-1.099,1.214]
Yr12*Revenue: Other (ref: commercial)	-0.505 [-1.299,0.290]	-0.341 [-1.312,0.630]	-0.795 [-2.170,0.580]	0.433 [-0.559,1.426]
Yr12*Ownership: Hosp./system/HMO (ref: phys.)	15.123 [-2.649,32.895]+	22.124 [-0.819,45.067]+	24.547 [-3.434,52.528]+	16.502 [-9.660,42.663]
Yr12*Ownership: Other (ref: physician owned)	16.017 [-7.420,39.455]	15.282 [-19.060,49.624]	31.533 [-8.159,71.226]	-17.397 [-70.892,36.097]
Yr12*Received patients from an IPA/PHO	-3.825 [-25.277,17.628]	-11.696 [-39.994,16.601]	-14.690 [-48.772,19.392]	-7.555 [-41.484,26.374]
Yr12*Bonus income for quality/efficiency (0-2)	0.373 [-11.803,12.549]	-0.313 [-15.010,14.385]	-2.842 [-22.725,17.041]	4.171 [-11.567,19.909]
Yr12*Bonus income for IT	16.933 [-4.918,38.784]	19.200 [-6.909,45.310]	17.780 [-17.787,53.347]	22.001 [-12.474,56.477]
Yr12*Physicians per 1000 persons	-1.574 [-4.887,1.739]	-1.719 [-6.366,2.929]	-1.740 [-7.593,4.113]	-0.811 [-5.864,4.243]
Yr12*Number of hospitals	-0.275 [-0.432,-0.119]**	-0.280 [-0.478,-0.082]**	-0.174 [-0.473,0.125]	-0.514 [-0.843,-0.184]**
Yr12*HMO penetration rate	0.140 [-0.340,0.619]	0.174 [-0.409,0.757]	0.366 [-0.475,1.206]	-0.062 [-0.691,0.567]
Yr12*Non-metropolitan area	-6.409 [-29.231,16.413]	-1.601 [-27.618,24.416]	-6.593 [-44.497,31.312]	8.531 [-19.415,36.476]
Constant	17.029 [-22.896,56.954]	16.469 [-31.723,64.661]	-9.208 [-73.033,54.617]	58.248 [-4.740,121.235]+
N	202	202	202	202
R-squared (within)	0.635	0.603	0.624	0.39
Adjusted r-squared (within)	0.563	0.525	0.55	0.271

Notes: +p<0.10; *p<0.05; **p<0.01. N=202. This table shows results from ten separate regressions. Standard errors were clustered by physician organization to account for non-independence between the same organization over time. Data source: The cohort of medical groups responding to both the National Study of Physician Organizations II (March 2006 - March 2007) and the National Study of Physician Organizations III (January 2012 – ongoing; data from responses up to March 2013).

Table D4b: Effect of organizational characteristics and external factors on the change in adoption of HIT from 2006-2012, large medical groups, results from linear regression with fixed organizational

	Externally oriented HIT index	Interoperability index
Yr12	44.003 [6.748,81.259]*	73.351 [13.499,133.203]*
Practice size, log	8.433 [-2.964,19.830]	12.707 [-2.992,28.406]
Specialty mix: Multispecialty (ref: prim. care)	-2.336 [-39.123,34.451]	-0.684 [-46.132,44.764]
Specialty mix: Specialty (ref: prim. care)	-14.322 [-34.392,5.749]	-25.445 [-54.156,3.266]+
Patient-centered management index (0-5)	2.998 [-0.996,6.993]	2.884 [-2.913,8.680]
Participated in QI program	-4.916 [-19.088,9.256]	-3.889 [-25.943,18.166]
Revenue: Medicare (ref: commercial)	-0.477 [-1.036,0.082]+	-1.044 [-1.946,-0.142]*
Revenue: Medicaid (ref: commercial)	0.233 [-0.347,0.813]	-0.035 [-0.990,0.920]
Revenue: Uninsured (ref: commercial)	0.519 [-0.256,1.294]	0.897 [-0.287,2.081]
Revenue: Other (ref: commercial)	0.563 [-0.166,1.291]	1.127 [-0.045,2.300]+
Ownership: Hospital/system/HMO (ref: phys.)	8.573 [-10.636,27.782]	25.599 [-5.205,56.403]
Ownership: Other (ref: physician owned)	14.685 [-21.633,51.004]	65.034 [15.108,114.959]*
Received patients from an IPA/PHO	-1.146 [-14.910,12.617]	-9.502 [-30.120,11.116]
Bonus income for quality/efficiency (0-2)	-1.587 [-11.983,8.809]	-0.015 [-17.397,17.367]
Bonus income for IT	-0.546 [-19.956,18.864]	2.421 [-25.812,30.653]
Yr12*Practice size, log	-7.316 [-14.906,0.273]+	-15.343 [-27.237,-3.450]*
Yr12*Specialty mix: Multispec. (ref: prim. care)	4.896 [-33.125,42.917]	-4.587 [-53.053,43.879]
Yr12*Specialty mix: Specialty (ref: prim. care)	-0.578 [-31.891,30.734]	28.193 [-11.051,67.437]
Yr12*Patient-centered management index (0-5)	-2.067 [-8.811,4.676]	-3.369 [-13.101,6.364]
Yr12*Participated in QI program	4.658 [-13.774,23.091]	4.623 [-23.085,32.330]
Yr12*Revenue: Medicare (ref: commercial)	0.132 [-0.406,0.671]	0.121 [-0.662,0.904]
Yr12*Revenue: Medicaid (ref: commercial)	-0.226 [-1.111,0.659]	-0.096 [-1.404,1.211]
Yr12*Revenue: Uninsured (ref: commercial)	-0.027 [-0.981,0.926]	0.142 [-1.278,1.562]
Yr12*Revenue: Other (ref: commercial)	-0.763 [-1.653,0.127]+	-1.493 [-2.837,-0.148]*
Yr12*Ownership: Hosp./system/HMO (ref: phys.)	4.448 [-14.541,23.437]	6.044 [-23.619,35.707]
Yr12*Ownership: Other (ref: physician owned)	17.377 [-18.180,52.935]	-15.291 [-62.949,32.368]
Yr12*Received patients from an IPA/PHO	8.071 [-12.828,28.970]	21.817 [-8.435,52.068]
Yr12*Bonus income for quality/efficiency (0-2)	1.426 [-12.515,15.366]	7.400 [-16.889,31.689]
Yr12*Bonus income for IT	13.505 [-13.874,40.885]	3.590 [-36.212,43.392]
Yr12*Physicians per 1000 persons	-1.319 [-5.251,2.614]	-3.166 [-8.707,2.375]
Yr12*Number of hospitals	-0.270 [-0.442,-0.098]**	-0.290 [-0.558,-0.021]*
Yr12*HMO penetration rate	0.095 [-0.427,0.618]	0.379 [-0.415,1.172]
Yr12*Non-metropolitan area	-13.943 [-40.634,12.748]	-25.581 [-63.078,11.915]
Constant	17.118 [-30.462,64.698]	28.221 [-46.213,102.655]
N	202	202
R-squared (within)	0.497	0.459
Adjusted r-squared (within)	0.398	0.353

Notes: +p<0.10; *p<0.05; **p<0.01. N=202. This table shows results from ten separate regressions. Standard errors were clustered by physician organization to account for non-independence between the same organization over time. Data source: The cohort of medical groups responding to both the National Study of Physician Organizations II (March 2006 - March 2007) and the National Study of Physician Organizations III (January 2012 – ongoing; data from responses up to March 2013).

Table D4c: Effect of organizational characteristics and external factors on the change in adoption of HIT from 2006-2012, large medical groups, results from linear regression with fixed organizational effects

	Electronic prescribing	EHR connects to EHR of main hospital	Email	Access EHR online
Yr12	114.911 [55.089,174.733]**	-67.051 [-130.517,-3.586]	-16.776 [-90.592,57.040]	56.885 [-10.420,124.191]+
Practice size, log	4.701 [-12.169,21.570]	10.708 [-4.772,26.187]	3.639 [-15.503,22.780]	1.862 [-17.381,21.105]
Specialty mix: Multispecialty (ref: prim. care)	-17.710 [-76.100,40.680]	-0.396 [-86.706,85.915]	-24.524 [-103.621,54.573]	28.331 [-39.173,95.835]
Specialty mix: Specialty (ref: prim. care)	9.319 [-17.532,36.171]	-9.853 [-42.371,22.665]	-12.532 [-51.837,26.772]	-10.851 [-40.850,19.148]
Patient-centered management index (0-5)	0.371 [-5.984,6.726]	0.039 [-7.361,7.439]	5.830 [-1.336,12.996]	6.095 [0.038,12.153]*
Participated in QI program	-1.590 [-23.031,19.850]	-5.675 [-28.373,17.022]	-12.315 [-41.056,16.427]	-3.163 [-26.603,20.276]
Revenue: Medicare (ref: commercial)	-0.319 [-1.243,0.604]	-0.909 [-1.873,0.056]+	0.713 [-0.394,1.820]	0.309 [-0.580,1.198]
Revenue: Medicaid (ref: commercial)	0.647 [-0.061,1.356]+	-0.157 [-0.825,0.511]	0.413 [-0.412,1.238]	0.833 [-0.013,1.680]+
Revenue: Uninsured (ref: commercial)	-1.589 [-3.026,-0.152]*	1.296 [-0.324,2.916]	1.011 [-0.625,2.646]	0.223 [-1.828,2.273]
Revenue: Other (ref: commercial)	0.438 [-0.721,1.598]	0.299 [-0.972,1.571]	-0.696 [-1.857,0.464]	0.516 [-0.869,1.900]
Ownership: Hospital/system/HMO (ref: phys.)	-11.273 [-41.788,19.242]	-33.994 [-69.300,1.312]+	26.349 [-15.590,68.288]	2.130 [-33.978,38.238]
Ownership: Other (ref: physician owned)	24.404 [-24.851,73.659]	-1.938 [-65.425,61.549]	-36.590 [-112.626,39.447]	-78.179 [-131.576,-24.782]**
Received patients from an IPA/PHO	1.753 [-23.233,26.738]	-0.337 [-25.294,24.620]	6.203 [-20.907,33.313]	12.866 [-9.348,35.079]
Bonus income for quality/efficiency (0-2)	-10.769 [-27.893,6.355]	-15.661 [-32.436,1.113]+	7.849 [-10.621,26.318]	7.517 [-10.457,25.491]
Bonus income for IT	-1.739 [-32.487,29.009]	-2.888 [-34.234,28.458]	-5.829 [-41.141,29.483]	-0.628 [-31.495,30.239]
Yr12*Practice size, log	-13.794 [-26.354,-1.235]*	-0.381 [-11.407,10.646]	5.422 [-9.150,19.994]	3.568 [-9.664,16.800]
Yr12*Specialty mix: Multispec. (ref: prim. care)	48.490 [-12.613,109.593]	24.848 [-64.683,114.379]	3.242 [-76.125,82.608]	-28.546 [-97.205,40.113]
Yr12*Specialty mix: Specialty (ref: prim. care)	-49.802 [-110.593,10.989]	-33.898 [-118.012,50.216]	2.864 [-64.805,70.534]	-7.790 [-76.143,60.562]
Yr12*Patient-centered management index (0-5)	-3.735 [-13.244,5.774]	-0.756 [-11.729,10.216]	-4.768 [-16.426,6.889]	4.894 [-5.222,15.010]
Yr12*Participated in QI program	-15.360 [-47.682,16.963]	-2.095 [-28.795,24.605]	30.696 [-9.342,70.733]	5.498 [-27.984,38.981]
Yr12*Revenue: Medicare (ref: commercial)	0.182 [-0.663,1.026]	1.031 [0.044,2.018]*	-0.347 [-1.600,0.906]	-0.304 [-1.296,0.688]
Yr12*Revenue: Medicaid (ref: commercial)	-1.177 [-2.671,0.316]	0.371 [-0.908,1.649]	0.521 [-0.857,1.898]	-1.009 [-2.383,0.365]
Yr12*Revenue: Uninsured (ref: commercial)	1.601 [-0.029,3.231]+	-0.400 [-2.235,1.435]	-1.212 [-2.863,0.440]	-0.606 [-2.582,1.369]
Yr12*Revenue: Other (ref: commercial)	-0.901 [-2.210,0.407]	-0.088 [-1.664,1.488]	0.834 [-0.518,2.186]	-0.707 [-2.299,0.885]
Yr12*Ownership: Hosp./system/HMO (ref: phys.)	14.246 [-15.963,44.455]	19.197 [-13.275,51.668]	-16.530 [-57.017,23.957]	-3.909 [-35.463,27.645]
Yr12*Ownership: Other (ref: physician owned)	33.275 [-21.549,88.098]	41.315 [-25.240,107.869]	17.818 [-38.491,74.127]	75.106 [16.516,133.696]*
Yr12*Received patients from an IPA/PHO	-9.624 [-45.998,26.750]	3.092 [-30.174,36.358]	2.944 [-40.547,46.435]	-5.365 [-40.682,29.953]
Yr12*Bonus income for quality/efficiency (0-2)	0.956 [-24.141,26.052]	12.405 [-6.797,31.606]	-7.720 [-42.383,26.942]	-17.860 [-46.395,10.674]
Yr12*Bonus income for IT	27.104 [-13.659,67.866]	30.295 [-17.714,78.305]	7.429 [-45.891,60.749]	18.939 [-22.635,60.514]
Yr12*Physicians per 1000 persons	-0.096 [-6.478,6.287]	2.184 [-4.440,8.808]	-1.688 [-8.741,5.365]	-0.133 [-6.984,6.717]
Yr12*Number of hospitals	-0.403 [-0.753,-0.054]*	0.011 [-0.341,0.363]	-0.417 [-0.932,0.098]	-0.211 [-0.639,0.217]
Yr12*HMO penetration rate	-0.086 [-1.036,0.863]	-0.362 [-1.269,0.546]	0.295 [-0.797,1.388]	-0.317 [-1.310,0.677]
Yr12*Non-metropolitan area	12.240 [-26.565,51.045]	-25.030 [-67.604,17.544]	-15.105 [-58.612,28.402]	7.037 [-38.460,52.535]
Constant	35.197 [-44.183,114.577]	38.492 [-37.137,114.120]	-14.904 [-99.964,70.156]	-23.623 [-105.629,58.383]
N	202	202	202	202
R-squared (within)	0.688	0.365	0.254	0.545
Adjusted r-squared (within)	0.626	0.24	0.107	0.456

Notes: +p<0.10; *p<0.05; **p<0.01. N=202. This table shows results from ten separate regressions. Standard errors were clustered by physician organization to account for non-independence between the same organization over time. Data source: The cohort of medical groups responding to both the National Study of Physician Organizations II (March 2006 - March 2007) and the National Study of Physician Organizations III (January 2012 – ongoing; data from responses up to March 2013).