A Multi-Agent Approach for HIE Design and Implementation

Full paper

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Abstract

Inadequate patient information sharing is one of the major challenges of the US healthcare system. Some scholars believe that Healthcare Information Exchange (HIE) provides a viable solution for the problem. The past decade has seen many state and regional healthcare providers trying to set up HIE. The implementation of HIE, nonetheless, has encountered many difficulties. Using grounded theory approach, we present a qualitative study trying to identify the success and hindrance factors for the development of HIE. Specifically, through the lens of agency theory, we found that divergence of interests of HIE participants leads to inefficient HIE inter-organizational information system design and implementation. A multi-agent based IT system design framework is proposed to reduce the multi-agent problem.

Keywords

Healthcare information technology, healthcare information exchange, agency theory, inter-organizational information system design

Introduction

The healthcare system in the US faces huge challenges. For example, Cutler and Sahni (2013) reported that the total healthcare expenditure of the US in 2012 was $514 billion, or 18 percent of the nation’s economy (Werling, Nyhus, Horst, Meade, & Wittek, 2014). Yet at this high cost, the quality of healthcare is in doubt (Reckmann, Westbrook, Koh, Lo, & Day, 2009). These challenges have raised many concerns, and some researchers (Hillestad et al., 2005) believe that healthcare information technology (HIT) offers at least partial solution to the problems. One important component of HIT is Healthcare Information Exchange (HIE). For example, Frisse and Holmes (2007) concluded that HIE can decreases in laboratory and radiographic tests, reduce admissions, and lower overall emergency department costs. Shapiro, Kannry, Kushniruk, and Kuperman (2007) argued that HIE is crucial to improve efficiency, patient safety and quality.

Despite of the potential contributions of HIE, its development has been very slow. In fact, only a handful of States in the US have tried to implement statewide HIE initiatives, and some of the programs failed to continue after the outside funding ended (HealthIT.gov, n.d.). Multiple stakeholders are often perplexed by the difficulties encountered by HIE implementation. Among a handful of studies examining HIE, most investigate either the technical aspect of HIE (Li et al., 2001) or the experience of a particular stakeholder’s population (Shapiro et al., 2007), without examining the success of HIE (DeLone & McLean, 2003) from an inter-organizational level and a multi-stakeholder perspective.

Given the complexity of HIE (eg. the multiple interest groups’ involvement), it is possible that research in limited scopes might miss some of the vital factors that will either facilitate or hinder the development of HIE. The current research tries to address such a deficit. This paper makes two contributions. First, this research considers multiple stakeholders’ roles in affecting the success HIE. Second, given HIE’s potential
contribution to cost saving, quality improvement, and efficiency gains to the healthcare industry, the
current research offers potential solutions to some persistent problems of HIE implementation.

The reminder of the paper is developed as follows. First, we define HIE and describe its current
developments. Second, we provide detailed description and explanation of the research methodology for
the paper. Third, using agency theory, we explore enablers and barriers of HIE and present a multiple-
agent framework for HIE implementation.

**HIT and HIE**

According to Magrabi et al. (2012), HIT “broadly includes computer hardware and software used by
health professionals and consumers to support care.” We define HIT as any information technology that is
used in healthcare. HIE can be considered as a technological component of HIT, because it is the
information technology’s application of healthcare information exchange. To facilitate discussion,
building upon earlier research (eg. Simon, Evans, Benjamin, Delano, & Bates, 2009), our study provide
researchers with the following definition for HIE: “Healthcare Information Exchange (HIE) is the
exchange of patient healthcare information across different healthcare providers to provide better patient
care.”

**Agency Theory**

Jensen and Meckling (1976) argues that agency relationship exists whenever there is delegation of work
from one party (the principle) to another (the agent). Because the principle and the agent have divergent
interests, and because the principle cannot fully control the agents’ behavior due to reasons such as
information asymmetry, the agent might shirk or engage in self-serving behavior at the costs of the
principle (such as moral hazard).

Agency theory has been widely used in the study of strategic management (Godfrey & Hill, 1995) because
the corporate governance mechanism typifies the agent-principle relationship. Most literature that utilizes
agency theory focuses on the dyad relationship between the agent and the principle. It is worth noting that
the initial development of agency theory does not limit itself to the dyad relationship (eg. Jensen &
Meckling, 1976; Welbourne, Balkin, & Gomez-Mejia, 1995). As Jensen and Meckling (1976) pointed out:
“Agency costs arise in any situation involving cooperative effort by two or more people even though there
is no clear-cut principal-agent relationship (1976: 307).” Welbourne et al. (1995) explained that “Unlike
the vertical control system represented by the principal-agent dyad, mutual monitoring concerns the
reciprocal assessment of performance among individuals working on common tasks whose contributions
are evaluated and rewarded by a firm on the basis of a collective outcome. Mutual monitoring, which
deemphasizes dependence on superiors and instead places control in the bands of peers, is buttressed by
the common bond of agents whose interests are intertwined.”

We believe that multiple agent perspective is conducive for the understanding of HIE. Indeed, HIE
invariably involve multiple stakeholders, such as different healthcare providers, patients, insurance
companies, government agencies, HIE vendors. These stakeholders sometimes act as principals and some
other times act as agents, thus each HIE participant assuming due roles of both agent and principle. For
example, an HIE participating hospital needs patients’ medical records from other hospitals, but in the
meantime the hospital also needs to provide medical records to other hospitals when requested. When the
hospital act as the principle, the hospital faces the principle side of the agency problem, such as
motivating and trusting the information supplying hospitals to provide timely accurate medical record;
when the hospital act as the agent, the hospital also needs to take the consideration of the cost of
providing medical record information to other hospitals in a timely and accurate manner. The multiple
agent situation has been inadequately explored, and this work tries to not only use the theory to explain
the dynamics of HIE but also in the meantime try to develop the multiple agency theory.

**Setting of the Study**

The Health Information Technology for Economic and Clinical Health Act (HITECH Act, n.d.), a part of
the American Recovery and Reinvestment Act of 2009 (ARRA), required the Office of the National
Coordinator for Health Information Technology (ONC) to fund the Health Information Exchange in
different states. In early 2010, ONC granted 50 awards totaling $548 million to help states develop exchange of health information among health care providers (HealthIT.gov, n.d.). Florida’s Agency for Health Care Administration (AHCA), the awards receiving entity, received $20.7 million dollars to develop HIE (florida-hie.net, n.d.). The state of Florida subsequently selected Harris Corporation, a technology organization, to implement the HIE in the state. In addition, Florida also selected some independent research agencies to evaluate the project. This study is data from this evaluation, which was conducted July 2011 through February 2014. During this period, multiple sessions of interviews and meetings were conducted and some were recorded. A portion of the recordings were also transcribed.

The technical creation of the Florida HIE is contracted to the Harris cooperation (Harris thereafter). Harris is an international communications and information technology company which has a wide range of diverse services such as transportation and defense. Its healthcare products have been implemented at the enterprise, state and regional level.

Two major HIE technologies are used for HIE which implemented by Harris: Patient Look-Up and Direct Secure Messaging. According to Florida-hie.net (n.d.), Patient Look-Up (PLU) service allows retrieval of records from multiple data sources at point of care after patient consent. Patient matching is based on demographic information. When clinical records are available at the point of care patients receive more accurate and timely service. In contrast, Direct Secure Messaging (DSM) allows users on different electronic health record systems to securely exchange summary of care records in order to meet transition of care meaningful use requirements.

Healthcare providers agreeing to participate the program are called “on-board” providers. The on-boarding hospitals receive matching funds for the implementation of HIE. Once Harris won the contract, it proceeded to implement the HIE solutions for the on-boarding providers. Apparently, many onboard stakeholders created the classic multiple agent problem because they were unlikely to have the same goals.

Methods

We utilize the grounded theory (Glaser and Strauss, 1967) for the current study because this method is very suitable for new theory development and new research phenomena exploration. We believe that new theory is urgently needed for HIE research. One reason is that HIE is inherently cross-disciplinary, where multiple factors such as technology, healthcare economics, legal and political environment, and organizational strategy all exert significant influence on the outcome of HIE. As such, the traditional single discipline research methods are often inadequate; instead, a multi-disciplinary approach is more suitable. Grounded theory is thus a powerful tool for developing new cross-disciplinary theories. We select grounded theory also because qualitative methods in general are more suitable than quantitative methods in exploring new empirical phenomena (Malterud, 2001). In fact, the HIE research is still in its infancy, where only a handful researchers have explored the topic. Orlikowski (1993) categorized that grounded theory to be inductive and contextual (Martin & Turner, 1986). The inductive approach of grounded theory for the research of HIE is particularly suitable because, as Orlikowski stated, grounded theory is a “generative approach” that are useful for studies that had no prior theories to build upon.

Grounded approach emphasizes iterative data collection (Glaser and Strauss, 1967). The rich data collected during the 3 year period offers the author of the paper, one of the co-investigators for the evaluation project, a unique opportunity to not only evaluate the success of the HIE initiative but also gain insights regarding the success and failure factors that impact Florida HIE. Due to the funding and timing limitations, nonetheless, only 5 interviews were professionally transcribed by contracting agencies, which are the main source of the current data analysis. The interviews accumulated for the past three-year period (herein named the 1st round of interviews) are conducted from a diverse group of stakeholders of Florida HIE including physicians, technical professionals, and a local HIE director. All these people have been deemed to have substantial exposure of the Florida HIE project. In addition, because of their diverse backgrounds, they offer unique insights from different perspectives. After the initial analysis of the data, we felt that we also needed insights from the patients’ perspective and we thus conducted telephone interviews (herein the 2nd round of interviews) with 5 patients from a convenience sample to gain more insights. Such a data collection method is one of the generally accepted and widely used approach of grounded theory development (Glaser & Strauss, 2009). The telephone interviewees included a retiree, a government agency worker, a student, and two self-employed professionals. In all, 5 archival interviews
for HIE stakeholders and 5 patient convenience sample interviews for patients totaling about 100 pages of transcripts are used for the current study.

Each round after the data was collected, we used the typical three stage coding scheme, namely free coding, axial coding and selective coding, to code the data (Strauss & Corbin, 1990; Seidel, Recker, & Vom Brocke, 2013). We conducted analysis using Nvivo qualitative data research software package (Nvivo version 9). To closely follow the research guideline offered by Glaser and Strauss (1967), we tried to structure data collection and analysis in an iterative manner. For example, the archival interviews for HIE stakeholders are used for the first round, initial open coding. Once the codings were analyzed, some initial insights were gained. These insights were subsequently used to guide us for the second round of data collection, namely the second round of interviews of the patients. Then the data was analyzed in the same fashion.

**Results**

**Enablers of HIE**

Almost all interviewees hold positive opinions of HIE (if it works), and mentioned benefits that generally falls into the following several categories: quality, time savings, cost reduction, ease for a mobile population, reduced waste. For example, David, an ER doctor, emphasized the benefit of the reduction of duplicated testing:

“We think the most substantial benefit that we see is avoiding unnecessary duplicative testing, diagnostic testing because people frequently are at E.R.s with a complaint and it turns out that they have been to three E.R.s with the same complaint since last two weeks and just didn’t like the answers they got so they’re going somewhere else to get a better answer but that they’ve already had the blood work and the ultrasound and the x-ray and the this and the that but they’ve already had that a couple of times. Or that there’s somebody who just is not a very good historian and can’t remember if they had a CAT scan or an MRI scan, how long ago it was and where it was but actually it was 60 days ago and here’s the report kind of thing. We think that is likely to be the greatest public good in terms of just not spending useless money on repeating tests that have already been done.”

Peter, a technical specialist, sees the benefit from a different perspective:

“So the most scary parts of coordination of care is what we call transitions in care from ambulatory to inpatient, from inpatient to rehab, from inpatient to home, from inpatient to somewhere else. It’s a pretty scary statistic when a treating primary care physician doesn’t have that information. So we want to see those things closed. You want to see the medications errors reduced.”

Peter also agrees with David about reducing of duplicated testing:

“You want to see the duplicate tests and – we’ve been there. So the estimates are 30 percent of the tests performed are unnecessary and duplicative lab tests and it’s because the treating physician at that moment at that point of care doesn’t have access to the records.”

Despite some of the strong criticisms that Peter voiced during the interview, regarding the prospect of HIE, Peter’s opinion is quite obvious:

“We may sound negative but we’re a firm believer in health information exchange and health information technology…”

Apparently, HIE is extremely useful, but the current utilization is also plagued with problems.

**Barriers of HIE**

The most intriguing discovery from the interviews is that people spoke more frequently about the barriers to implementing HIE. As we analyze the data trying to identify barriers that hinder the development of HIE, a central, higher-level theme emerges, which revolves around the agency costs. Although undoubtedly other barriers exist, pertaining to the current discussion, only the several key barriers that related to agency costs are identified.
Multi-Agent Approach of HIE Design

Workflow

One frequently mentioned barrier factor is related to HIE’s impact on workflow. The overall impression is that Harris apparently failed to take this factor into consideration, which has very negative impact on the users of HIE, namely, physicians and nurses. For instance, Peter makes the following complaints:

“The other big barrier is that physicians and providers want everything to connect to what we call their native systems in their office. That is their dashboard. That is their central nervous system of their belly button as we say. We’re sure you use Microsoft Office, right?... So everything we do goes through there. For a physician that is either their practice management system or their EMR. Most of them are integrated and many of those are becoming one. So if it doesn’t integrate with their native systems the physicians aren’t going to go out there and sign on, sign off, remember another password because it’s outside of their clinical workflow.”

Other interviewees are even more critical. When Pam, a director of a regional HIE, was asked about the HIE vendor’s performance, she commented:

“We think SHI has a portal and we think others have portals that you have to log on and do a search and try to find a patient. They’ll have to leave their EHR, go and do this and then come back. We failed, the time required to doing that, most people will not do that or it’ll be too difficult.”

What is obvious is that the designer of the HIE system neglected the needs of one of the largest stakeholder groups—doctors and nurses. A plausible reason for such a negligence is that Harris, the technology system builder, was only asked that their HIE products to fulfill the function of information exchange, and anything beyond is not part of the job description. As such, the system at best is a seriously flawed one because most of the designed users are not even wanting to use it.

Competing Healthcare Providers

Another barrier is the competition of competing (especially local) healthcare providers. David makes it explicit:

“There are two or three major barriers that we see. The most important initial barrier we think is going to be turf of our – are you going to be able to get competing hospitals or competing facilities who are in the same town to share?”

Once again, this is a very typical multi-agent problem, which might leave the whole HIE project without participants if no providers want to share their patient data for fear of that their own patients might be stolen.

Sustainability

Peter indicated another barrier of the concerns of sustainability. Peter:

“The other big barrier is they don’t know that the HIE is going to be there in the future and there’s been fits and starts in Florida in the past. So we think there’s a wait and see attitude that the physicians are not going to sign up to use the service because they’re just, “Hey, we don’t know if they’re going to be here in two years, man.” They might sign up now because this can help them qualify for meaningful use but it’s still going to be a challenge.”

In an environment where multiple free-agents present, the uncertainty of future drastically increase because each agent can make their independent actions which will impact the outcome of the group. In such situations, coordination is of tantamount importance.

Multiple Agent Problem and Multi-Agent Based System Design

Multiple Agent Problem

The above-mentioned problems share the same cause of the agency problem, discovered by axial coding, where multiple agents try to maximize their own interests. Apparently, multiple stakeholders jointly influences the success of HIE, which creates very intricate dynamics. After the author carefully examined
the data through iterations, this multiple agent problem emerges as the core category. According to Strauss and Corbin (1990), the core category is the center of the process being explored of a research. The multiple agent problem is deemed to be the underlying cause for the main barriers for HIE development.

**Convergence of Large Common Goals**

Because the participation of HIE is largely voluntary, different participants decide to be on board only when they decide that the participation of HIE will benefit them more than it costs them. As such, the expectation for the participation of HIE, or the formation of such a multiple agent relationship, is that if the common goal is achieved, every participant will be better off. In practical terms, the benefits can be the secure, timely access of patient medical record data when needed. In actuality, the development of the system that serves the common goal is an extremely complex undertaking, as discussed below.

**Divergence of Smaller Individual Goals**

The divergence of smaller individual goals are due to two reasons. One is from the inherent differences of needs of the participation parties. For example, many of the medical institutions' motivation for HIE is to obtain patients medical records that is otherwise unavailable, whereas the governmental agency's participation can be for the more overarching goal of improving public health. The divergence of interests inevitably leads to the conflicts of resource allocation, because of the limited resources of any HIE. What complicates the matter is that for many HIEs, the standards protocol of information exchange has to be agreed upon and subsequently developed. The protocol, as any information systems artifacts, is to serve a certain purpose of the system design, and the system design is to driven by the design principles, such as how the common goal as well as each participants' individual goals to be served. Because all HIE participants' interests are not fully aligned, the information system artifact will reflect this incongruence, which will be shown as some of the inefficient and imperfect system functions in operations. However, at the beginning stage of the HIE alliance, many of the system design details are not fully discussed, agreed upon or even understood by the participating parties. Often, the information system artifacts were developed despite the fact that serious differences have not be resolved. Thus, when the artifact is developed and implemented, it is inevitably leads to participants’ conflict of interests and dissatisfaction of the system during system use.

**Multi-Agent Based System Design**

Further investigation of the data shows some other interesting themes. For example, many problems seem to root from a less-than-perfect system design, because apparently, the system provider, Harris, fail to take consideration of many of the stakeholders. The reasons for that to happen, nonetheless, are not that straight-forward. In fact, the major theories and paradigms of IS research dealing with system design seem to consider a single organization (although often multiple users and stakeholders within one organization are involved) by default regardless of the size of the organization (eg. an ERP system for one company), without considering the systems where diverse stakeholders’ interests are at play, such as the case of HIE. The design of HIE from Harris had certainly followed the traditional approach, and when the system is in function and problems arise, no easy solutions can be found unless the system is redesigned. The misfit of the traditional signal organization focused system design misalignment is shown in Figure 1.
Multi-Agent Approach of HIE Design

To remedy, at the system design phase, multiple users’ needs must be considered and reflected in the design. For instance, to satisfy physicians’ needs, physicians’ workflow should be carefully studied so that HIE will not create/become additional burden for the physicians. For example, as one doctor hinted in the interview, the HIE system user interface should in fact be integrated to the “dashboard” of the physicians’ interfaces rather than create two parallel systems. Similarly, as another interviewee mentioned, HIE has the potential negative impact of reducing hospitals’ revenue because of the reduction of duplicated tests or patients switching providers. Apparently, these factors might negatively impact system use, which is an agency self-interest alignment problem which has nothing to do with the narrowed defined system quality. Thus as early as at the IS system design phase for the HIE system, this agency problem should be addressed so that future dis-incentive of system use can be averted.

One of the challenges of HIE is that there is not a centralized agency to coordinate all these needs and as a result, HIE systems are often developed piece-meal and many problems surface only after the systems were implemented. It is thus argued that for systems that involve multiple agents, a multi-agent based information system design should be developed. Such a system design takes consideration of the conflicts of interests of multiple participants, and try to maximally reduce these negative impacts (Figure 2). This advantage is especially salient when multiple agents have obvious of divergence of interests and goals. The multi-agent based system design takes into the consideration of the possible conflicts of different participating parties of the information system and try to reconcile the differences at the design phase.

**Figure 1. Traditional Single User System Design and Non-Optimal System Use**

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**Figure 2. Multi-Agent Based System Design and Optimal Use**

The discussion of the details of the multi-agent system design is beyond the scope of the current study. At its minimum, the potential conflicts of multiple agents should be enumerated so that ramifications discussed. Solutions for issues that might result in conflicts should be developed and agreed upon which
must be included in the IS software development specifications so that both the social and technical considerations are taken into account.

Conclusion

This study utilizes the grounded theory approach to investigate the implementation of Florida HIE with the focus on the barriers’ of such a system development. First, the project is briefly reviewed and the interview data analyzed. It is shown that when multiple agents are involved with divergent interests, it is difficult for the traditional IT system design approach to yield satisfactory results. Instead, a more multiple agent based approach is needed which promises better results.

The study makes several contributions. First, this study advances the understanding of HIE research and implementation. As indicated earlier, despite the importance of HIE, many of its implementations achieved only limited success, with one reason being the social complexity of HIE. Second, the study explores the dynamic of multiple agents’ impact on IS design and implementation, and suggests solutions for improved IS system design when multiple agent problem present. Third, the study also enriches the agency theory by empirically exploring the under-studied multiple-agent dynamics. Fourth, this research has important empirical implications. For example, the findings of the study provides researchers as well as practitioners with viable solutions for future HIE development. In addition, the insights gained from studying the multiple-agent relationship can be readily extended to other fields of industry.

REFERENCES


Multi-Agent Approach of HIE Design


