**Understanding information exchange in healthcare operations:**

**Evidence from hospitals and patients**


## Abstract

Coordination – or the information exchange among physicians and hospital staff – is necessary for desirable patient outcomes in healthcare delivery. However, coordination is difficult because healthcare delivery processes are information intensive, complex and require interactions of hospitals with autonomous physicians working in multiple operational systems (i.e. multiple hospitals). We examine how three important variables distinctive of the healthcare operations context – use of IT for dissemination of test results (ITDR) (i.e. Electronic Health Records systems) by physicians and hospital staff, social interaction ties among them, and physician employment – influence information exchange and patient perceptions of their care. Drawing from the literature on process inter-dependencies and coordination, vertical integration and social exchange, we develop and test research hypotheses linking ITDR, social interaction ties and physician employment to information exchange relationship, and information exchange relationship to provider-patient communication. Using a paired sample of primary survey data and secondary archival data from CMS HCAHPS for 173 hospitals in the U.S.A., we find that increased information exchange relationship drives provider-patient communication, and increased social interaction ties drives information exchange relationship. Social interaction ties fully mediates the relationship between ITDR and information exchange relationship. Physician employment amplifies the link between ITDR and social interaction ties, but does not have an effect on the link between ITDR and information exchange. We do not find a direct relationship between ITDR, and information exchange relationship or provider-patient communication.

## 1. Introduction

Healthcare is delivered to hospitalized patients by providers such as physicians, nurses, and other clinicians. Coordination, or the information exchange relationship among providers in healthcare delivery, is necessary to achieve desirable patient outcomes (Boyer and Pronovost, 2010). Drawing on the operations and Information systems (IS) literatures, information exchange relationship is defined as accurate, timely, adequate, and credible information interchange among those involved in a particular process (Lee et al., 1997; Metters, 1997; Li et al., 2005). Unfortunately however, coordination is challenging given inherent difficulties in synchronizing operational activities and information in hospitals (Nembhard et al., 2009). Anecdotal patient accounts tellingly support and capture this challenge.

> *"The caregivers didn't appear to be talking to one another." This is how retired internist Marsha Wallace described her recent inpatient hospital stay in Kaiser Health News. "Although hospitals, the federal government, nonprofit groups and insurers want to improve the system, efforts to boost coordination and teamwork still have a long way to go,"* (Rabin, 2013).

> *"Without coordination, a patient can languish for weeks from one step to the next while her tumor grows and the illness progresses. Without integrated care, critical information is easily lost and treatment delayed or misdirected. Or, as happened to D'Agostino [a breast cancer patient], specialists offer complex and sometimes contradictory information to the patient who sorts it out alone."* (Toussaint, 2012).

Physicians have substantial influence on hospital operations and the services delivered to patients (Ilie et al., 2009). Therefore it is important for hospitals to find ways to improve coordination with physicians to improve patient experiences (Ancarani et al., 2011; Fredendall et al., 2009). The information exchange relationship among the physician and a hospital's healthcare providers is an essential element of coordination and key to delivering experiences which patients find valuable (Queenan et al., 2011). The overarching objective of this research is to understand key factors involved in achieving information exchange in healthcare delivery operations. We address our study objective by conceptualizing a model that takes into account three distinctive characteristics of the context of healthcare delivery processes, each of which can influence information exchange relationships.

The first characteristic is the information intensive and complex nature of healthcare processes (Nembhard et al., 2009). The adoption and use of electronic health records (EHR) represents a key to addressing this by providing a platform for information standardization, storage and access that has the potential to improve coordination among healthcare delivery providers (e.g. AHRQ, 2013; Angst et al., 2011). However, the operational consequences in terms of coordination from health Information Technologies (IT), and specifically from EHR use by physicians, nurses, and hospital staff have been mixed and inconclusive (McCullough, 2010; Queenan et al., 2011). Therefore, our first research question is: *Does coordination in the form of information exchange relationship among physicians and hospital's healthcare providers mediate the link between IT use and patient experiences?* IT use is modeled as an antecedent of information exchange relationships.

Second, physicians have traditionally functioned as "…owner-operator[s] of [their] own ongoing firm" when providing services to patients in a hospital setting (McLean, 1989: p. 67).

As a result, physicians tend to have higher professional than organizational loyalty and substantial autonomy (Nembhard et. al., 2009; Boyer and Pronovost, 2010). Under these conditions, the social interaction ties that characterize the relationships among the hospital staff/nurses and doctors is an important consideration (Fredendall et al., 2009). 'Social interaction ties' describes the configuration of linkages among people or units (Nahapiet and Ghoshal, 1998) which aids in coordination among individuals and units (He et al., 2009). Therefore, our second research question is: *What is the effect of the social interaction ties among the physician and the hospital staff in mediating IT use and information exchange relationship*? Social interaction ties is modeled as another antecedent of information exchange relationships, partially mediating the effects of IT use

Third, in response to the autonomy of physicians and complexity of healthcare delivery processes, increasingly hospitals are pursuing vertical integration strategies by employing the physicians who provide services to hospitalized patients with the hope of enhancing operational efforts to achieve coordination (e.g., Williamson, 1985). An 'employed physician' is a doctor who receives financial compensation from a hospital in exchange for treating patients (Schneller, 2001; Fink and Hartzell, 2010; Andrabi, 2012). Our third research question is: *What is the effect of vertical integration (physician employment) on the link between IT use and social interaction ties, and between IT use and information exchange relationship?* We draw from the social interaction ties and vertical integration literature to understand how IT use can improve coordination and ultimately patient outcomes, by modeling physician employment as a moderator of the relationships emanating from IT use to information exchange relationship and social interaction ties.

We address our research questions by developing research hypotheses and testing them using Structural Equation Modeling. Specifically, we analyze a matched dataset consisting of 1) primary survey data collected from hospitals measuring hospital practices and 2) secondary archival data collected from the Center for Medicare and Medicaid Services (CMS) Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) survey measuring service experiences as reported by patients. The study makes four theoretical contributions. First, we show that provider-patient communication can be enhanced by improved coordination in the form of information exchange relationships among healthcare providers (i.e., physicians and staff). Second, we reveal a fully mediating role for social interaction ties in the relationship between IT use and coordination. Third, we show that there is no *direct* relationship between IT use and provider-patient communication. Through these two findings, we highlight the difficulties in achieving information exchange based coordination *solely through use of IT*. In doing so, we extend current studies that focus on the role of social interaction ties industrial settings (e.g., Carey et al., 2011; Villena et al., 2011). Fourth, we show that vertical integration (in the form of physician employment) positively moderates the relationship between IT use and social interaction ties. Vertical integration has been considered in the context of inter-organizational IS (Xue et al., 2013). We describe and empirically demonstrate the importance of vertical integration in appropriating benefits from use of *internal* IS. Through these contributions we open the somewhat intractable EHR – patient outcomes black box (Poissant et al., 2005). Our study provides important insights for practitioners who recognize the need for better coordination in healthcare, but lament the challenges of actually realizing it even when EHR are implemented and used (Evans, 2008; Scott et al., 2005; Smelcer et al., 2009). We further provide direction

regarding the effects of physician employment in hospitals, an important point of discussion, with far from conclusive points of view (Andrabi, 2012).

## 2. Healthcare operational context and research model

A number of key aspects characterize work processes in healthcare delivery. First, the exact content of tasks needed to be performed for a given patient evolves during treatment to some extent (Nembhard et al., 2009). The processes of diagnosing and treating patients can follow some standard procedures such as testing, but often involve emergent tasks that require iteration among physicians, nurses and technical specialists (Tucker, 2004). Second, the order or flow of activities is often not in a given sequence, but involves recursive tasks of collecting data about patients, consultations among specialists, and diagnosis of the patient's condition (Malone and Crowston, 1994). Third, multiple and specialized providers are involved in diagnosis and treatment for a given episode of care for a patient (Leape, 2005). Further, providers need to exchange information, due to the growth and specialization of clinical knowledge and variety of conditions afflicting patients (Gittell and Weiss, 2004). Fourth, different care delivery processes occur in different locations (e.g. laboratories, hospital beds, imaging rooms), with potential information handoff problems among them (Kenagy et al., 1999; Boyer and Pronovost, 2010). These conditions increase the information intensive and complex nature of healthcare delivery and make coordination in healthcare operations difficult (Chen et al., 2013). As a consequence of inadequate communication or coordination among providers, important medical information is not available at the time of treatment and is thus impossible to share with patients (e.g., Green, 2012; Buell, 2013).

The implementation and use of health IT is seen as an important means to addresses the requirements of coordination (AHRQ, 2013). Agarwal et al. (2010) provide a comprehensive

literature review of health IT (and EHR) use and anticipated improvements. However, research shows mixed findings from the use of EHR systems. For example, studies report positive outcomes such as reduced costs (Li and Benton, 2006) and increased patient satisfaction (Queenan et al., 2011), negative outcomes such as increase in physicians' documentation time and workload, and reduced reporting flexibility (Poissant et al., 2005; Lahiri and Seidmann, 2012), as well as large variations in the extent of use (Dobrzykowski, 2012). While some studies show negative associations between EHR use and inpatient mortality and length of stay, others show little effect (Goh et al., 2011). Recent literature observations (e.g., Devaraj et al., 2013) suggest that, but do not explain why, lack of coordination in the healthcare delivery process may be an underlying reason why EHR systems have not yielded unqualified benefits.

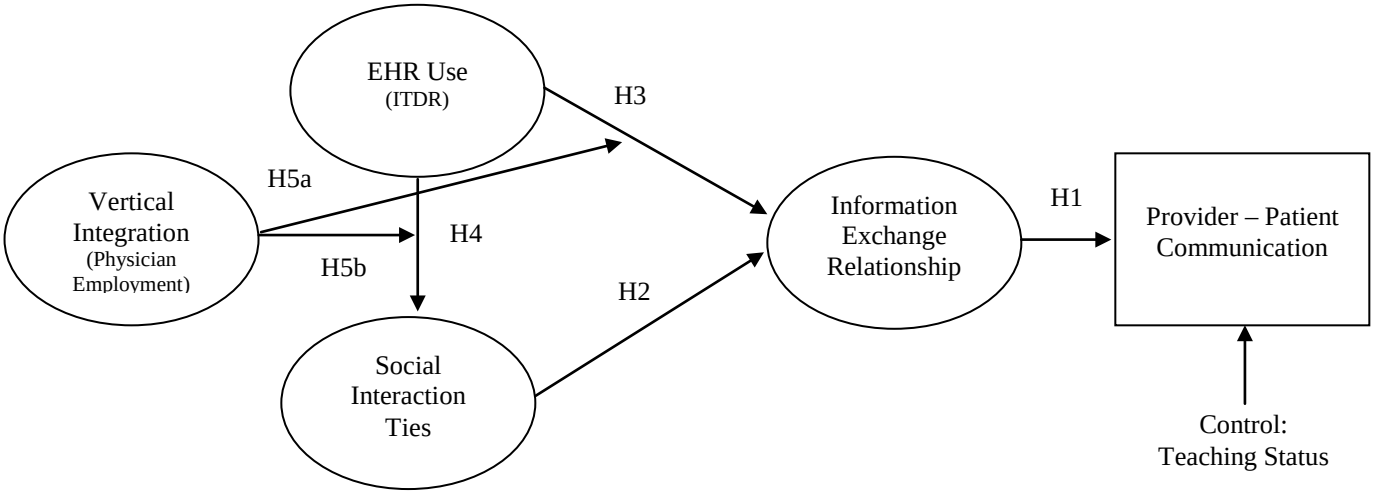
Social interaction ties can improve cooperative behaviors (Nahapient and Ghoshal, 1998) – information exchange relationship in the case of this study – which should positively influence patient experiences in the form of provider-patient interactions. EHR use can potentially build social ties by providing access to information (AHRQ, 2013; Prahalad and Ramaswamy, 2004). Social ties, in turn, are useful in overcoming the inherent challenges of coordination, such as the differentiation borne out of clinical specialization, enabling healthcare delivery providers to work as a team (Boyer and Pronovost, 2010). Strong social interaction ties between the physician and the hospital begets commitment among nurses, doctors and staff (Villena et al., 2011) and enhances information exchange among them.

We also recognize that, for many years, coordination has been hampered by the nature of the relationship between a physician and a hospital. Historically, this relationship has involved the physician being credentialed to admit and treat patients in multiple hospitals, and receive compensation for services from entities such as insurers who are outside of the physician –

hospital relationship (Ford and Scanlon, 2007). This method of service delivery exposes the physician to different operational and EHR systems and can result in a lack of financial alignment among physicians and hospitals. These factors make it difficult to easily achieve coordination among the physician and multiple hospital interfaces. Recently therefore, physician employment has emerged as a mechanism that facilitates the physician's work in a single operational environment and promotes alignment with a specific hospital employer (Fink and Hartzell, 2010; Schneller, 2001). This is rooted in the belief that by "integrating the physicians they employ, hospitals will be better positioned to improve clinical outcomes…" (Fink and Hartzell, 2010: p. 98). The underlying logic is that physician employment, akin to 'vertical integration', is expected to improve coordination (Williamson, 1985).

Considering these issues – namely, the potential to improve communication from EHR use, coordination challenges in healthcare operations, and momentum towards vertical integration (physician employment), we draw on logic from coordination and independencies (e.g. Thompson 1967, Malone and Crowston 1994) to explain how social interaction ties (Nahapient and Ghoshal, 1998) can link EHR use by physicians and staff to information exchange among them, and to superior experiences for patients. We also examine how these relationships are influenced by vertical integration (Williamson, 1985). The research model is illustrated in Figure 1.

Figure 1. Research Model.




## 3. Research Hypotheses

### *3.1. Improving provider – patient communication via coordination*

Changing hospital reimbursement methods are increasingly focusing on patients' perceptions of the services they receive, specifically provider-patient communication (Russell Bennett, 2012; RTI, 2011). Healthcare delivery occurs through an *inter-dependent* set of operational processes (e.g. testing, consultation, diagnosis, bedside procedures), executed by *independent* providers (e.g. physicians, nurses, staff), in a *fragmented* set of providers (e.g. hospital beds, laboratories, radiology departments) (de Blok et al., 2014). As a consequence, there is: 1) *uncertainty* (Galbraith, 1973), in that the exact information required at the point of "action" is not always fully known beforehand; 2) *differentiation* (Lawrence and Lorsch, 1976) in that providers involved (nurses, physicians, technicians) embody different bodies of knowledge, technical language and perspectives that can lead to differences of opinion; and 3) *interdependence* (Thompson, 1967) between activities, which could be sequential (e.g. diagnosis depending on appropriate tests being taken), reciprocal (e.g. a physician's diagnosis depends on

testing, medicine administration, bedside procedures, carried out by others), or shared responsibility (e.g. multiple providers - medical technicians, physicians, nurses - are responsible for a shared work goal - patient diagnosis and cure). An effective information exchange relationship among physicians and hospital staff provides coordination in managing these conditions (e.g., Malone and Crowston, 1994).

Based on the above, we theorize that individuals involved in healthcare delivery processes (i.e., doctors, nurses, and hospital staff) should be able to exchange information in a non-programmed, informal, and ongoing manner. Indeed, the majority of information transactions within a hospital are communications among patients, doctors, nurses, and the staff (Coiera, 2000). As a consequence of conditions involving uncertainty, differentiated knowledge, and interdependence among providers, the information exchanged is emergent, complex, time-sensitive, expertise-driven and tacit (Chen et al., 2013; Gittel and Weiss 2004, Tucker, 2004). Literature on information processing effectiveness (e.g., Doll and Torkzadeh, 1988; DeLone and McLean, 2003) suggests that the quality of information processed is important for conveying what it intended, and that such quality can be embodied by information that is accurate, timely, adequate and complete. In the operations and supply chain literature (Holweg and Pil, 2008), coordination expected from deployment of IT is strongly dependent on the nature of information shared; frequency, accuracy and timeliness of information are seen as key characteristics for effective coordination to take place. In the context of healthcare operations, Gittel et al. (2000) suggest that coordination should be embodied in frequent, timely and accurate communication among healthcare providers (e.g. physicians, nurses, staff), and is associated with improved quality of care and more efficient clinical outcomes. Drawing from these, we define information exchange relationship as accurate, timely, adequate, and credible information interchange among

those involved in a particular process. Such information exchange is expected to improve the performance of healthcare delivery as adverse hospital events such as medical errors have been linked to lack of communication and information sharing among doctors, nurses, and staff (White et al., 2004).

We focus on provider-patient communication as reported by the patient, as a measure of desired patient outcome. The provider's (i.e. staff/nurses and physician) communication with the patient is an important and desired outcome of healthcare delivery from the point of view of the patient for four reasons. First, the more the information communicated to the patient in terms of diagnosis, prognosis, explanations of benefits and risks, side effects, the more rationally patients are able to evaluate their options and the greater the chance of their complying with treatment protocols (Cegala 2006; Prahalad and Ramaswamy, 2004). Second, it influences the patient's health-related attitude and satisfaction in a positive way (Hagiwara et al., 2014). Third, physician-patient communication, in particular, is important for follow up appointments (Korsch, 2010). Fourth, the emergence of patient portals and other social and economic factors appear to be increasing patients' responsibility for several aspects of their own health care (Bauer, 2000). Provider-patient communication is key to ensuring that patients have information and understanding to be able to take on this responsibility. Today, provider–patient communication is recognized as a legitimate aspect of medical care and is included in undergraduate and postgraduate medical education (Korsch 2010).

'Provider–patient communication' is defined as doctors and nurses effectively providing medical information to patients (Ammentrop et al., 2014; Russell Bennett, 2012; RTI, 2011). Information exchange informs the environment within which providers perform their work, allowing them to perform more effectively (Vargo and Lusch, 2004; Schmenner et al., 2009). In

particular it embodies coordination of physicians with nurses and technicians, and thus enables better communication between the provider and patient. Thus we hypothesize,

> **Hypothesis 1.** Information Exchange Relationship is positively associated with Provider – Patient Communication.

*3.2 Social interaction ties and coordination*

Social interaction embodies nearness and communication between actors within and between organizations, and has been shown to explain improved information exchange, integration and coordination among buyers and suppliers (Cousins and Menguc, 2006, Cousins et al 2006). 'Social interaction ties' is defined as a willingness demonstrated by admitting physicians to expend efforts to work cooperatively with hospital staff (Krause et al., 2007; Villena et al., 2011; Carey et al., 2011). We suggest that it represents an important mechanism to enhance information exchange relationship, for the following reasons. First, we know that social interaction decreases the cost of transactions and increases the efficiency of resource exchange in general and information diffusion in particular (Nahapiet and Ghoshal, 1998). It has, for instance, been hypothesized to lead to knowledge contribution in open source communities (Wasko and Faraj, 2005). Second, social interaction ties enhance trust between partners (Carey et al., 2011), thus enabling information exchange in the context of operations management. Indeed, a key objective of developing social interaction ties is the subsequent access to information which results (Villena et al., 2011). In the context of this study, strong social interaction ties between the physician and hospital begets commitment among nurses, doctors and staff, motivating 'dense' interactions (Prahalad and Ramaswamy, 2004; Villena et al., 2011) among them and enhancing the information exchange relationship. Thus we hypothesize,

> **Hypothesis 2.** Social Interaction Ties is positively associated with Information Exchange Relationship.

### *3.3 Effects of EHR use*

Recent research suggests that use of EHR supports effective work practices by physicians (Goh et al. 2011). Because EHR use for results viewing represents a widely adopted and important application of IT in a clinical setting, we focus on IT Dissemination of Test Results (ITDR) (Jha et al., 2009). ITDR is defined as a hospital's healthcare delivery providers' (i.e. doctors, nurses and staff) utilization of electronic health records systems for viewing clinical results such as those from lab and radiology (Ash et al., 2004; Cutler et al., 2005; Jha et al., 2009). ITDR enables healthcare providers to exchange information (e.g., from a radiologist or radiology tech to an attending physician) necessary in treating patients. Unfortunately, while information exchange is critical to physician performance, clinicians often function without much needed information (Lahiri and Seidmann, 2012). ITDR enables healthcare delivery providers to record up-to-date, patient diagnostic information important to care delivery such as radiological and laboratory results (Jha et al., 2009), essentially turning the EHR into a platform that can form the basis of information exchange among providers. Such a platform keeps healthcare delivery providers informed about key parameters, so that they can share information about relevant issues with one another (Wasko and Faraj, 2005; Speier et al., 2011). Information exchange is key given that the use of EHR is more effective when the clinical staff act as a collaborative 'consulting team' that engages in ongoing information exchange enabled by ITDR, as opposed to a 'reporting shop' that just uses the system for entering patient information (Devaraj et al., 2013; Sobun, 2002). Much of the information exchanged is not always present in EHR systems, but is based on their outputs (Lahiri and Seidmann, 2012). ITDR therefore

represents an important approach for improving information exchange among healthcare delivery providers. Thus, we hypothesize,

**Hypothesis 3.** IT Dissemination of Test Results is positively associated with Information Exchange Relationship.

ITDR provides healthcare delivery providers with access to important patient information needed during healthcare delivery (Jha et al., 2009; AHRQ, 2013). As access to useful information increases, providers recognize the system's value as a key support resource in performing their work (Lahiri and Seidmann, 2012), and over time, information entered into the system by colleagues as the source of that value. Thus, providers develop commitment through demonstration of their respective competencies that enables them to provide useful information to the EHR system, and use it as a medium for communicating clinical information with one another, which strengthens social interaction ties among them (AHRQ, 2013). Thus, we hypothesize,

**Hypothesis 4.** IT Dissemination of Test Results is positively associated with Social Interaction Ties.

*3.4. Effects of vertical integration*

Vertical integration is suggested to be an effective operational approach when the burden of coordination is high and the potential for a lack of alignment exists with external partners (Handley and Benton, 2013; Williamson, 1985). Operations management researchers have utilized the idea of vertical integration to analyze partnering decisions among network associates (see Handley and Benton, 2012; Handley and Benton, 2013).

In healthcare delivery, vertical integration is relevant in considering hospitals' decisions to employ physicians (Ciliberto and Dranove, 2006; Cuellar and Gertler, 2006). With regard to coordination efforts, non-employed or 'independent' physicians can be considered as external

partners of the hospital, who also provide services in other facilities (Fredendall et al., 2009). When independent physicians often practice in multiple hospitals, coordination is challenged by a number of factors which include the necessity to manage: 1) logistical (travel) inefficiencies, 2) varying operating systems (e.g., rounding schedules, hospital discharge policies, and facility layouts), 3) diverse materials and supplies resulting from different hospital – vendor relationships, and most relevant to this study, 4) different EHR systems. As a result, the effort to coordinate these necessary activities detracts from the 'production of healthcare delivery' – patient care. Admittedly, not all non-employed physicians practice in multiple hospitals, however, with regard to a potential lack of alignment, non-employed physicians do receive remuneration from third-party payers outside of their relationship with the hospital. As such, the threat of a lack of alignment exists in that non-employed physicians may have different financial goals than the hospital, causing dissonance (Fink and Hartzell, 2010). Coordination efforts and the potential for a lack of alignment have in part motivated hospitals to consider employing a portion of their attending physicians. Initial research provides some evidence that more integrated healthcare organizations (i.e. those that have a greater percentage of employed physicians) achieved quality improvements without increasing prices (Cuellar and Gertler, 2006).

Employed physicians ought to be more familiar and comfortable with the IT systems of the hospital within which they work and further along the learning curve associated with ITDR. Because employed physicians share the financial goals of the hospital and through repeated ITDR use and working together over time, employed physicians and the hospital staff are able to improve their information exchange relationship and build social interaction ties. As a result,

physician employment should enhance the benefits derived from the hospital's EHR system. Thus, we hypothesize,

> **Hypothesis 5a.** Vertical Integration (Physician Employment) positively moderates the relationship between IT Dissemination of Test Results and Information Exchange Relationship.

> **Hypothesis 5b.** Vertical Integration (Physician Employment) positively moderates the relationship between IT Dissemination of Test Results and Social interaction ties.

## 4. Methodology

A paired dataset combining primary survey and secondary archival data were collected to test the hypotheses. Next, we describe the instrument development, the theoretical basis for the constructs and their measures, and data collection methods.

### *4.1 Instrument development*

A three-step process was used to develop measurement instruments for the survey. First, item generation was facilitated by a literature review to identify the domain of the constructs and generate the initial measurement items. The literature provides insight about how the variables were defined and their dimensions (Churchill, 1979) and is described in the next section. Second, a pre-test was conducted to refine the scales. This step involved interviews as part of an experience survey with two academicians and two practitioners possessing sufficient domain knowledge (Churchill, 1979). The researchers identified and invited participants based on: 1) the participant's previous involvement in relevant research projects, 2) the participant's reputations for knowledge of the study domain, and/or 3) relationships with the researchers' university. The participating academics are PhD qualified experts and are well published in the operations management field and information systems. The participating practitioners each possess 20 years of hospital-based and healthcare experience, primarily in the quality management area which is

highly relevant considering this study's focus on coordination in healthcare operations with an aim toward standardized measures of patient outcomes (HCAHPS). Upon final review of the survey items, 'practitioner one' commented that "I thought the survey was very easy to follow and to understand." 'Practitioner two' opined, "I like the scale; the questions are worded in a way that anyone with hospital knowledge should be able to answer them and, specifically, any administrator or manager should be able to answer the questions for their own organization. Two thumbs up."

Finally, six healthcare executives with significant hospital-based experience participated as judges in the Q-sort process to further refine the items in the final step of instrument development (Churchill, 1979). Again, the criteria described in the preceding paragraph was used to identify Q-sort judges. The study-related domain knowledge of the judges was confirmed by the researchers and is evidenced in their job titles which include: President of Physician Services and Clinical Integration, Ambulatory Medical Information Officer, Service Line Vice President, Clinical Director and Department Chair, Regional Manager of Physician Relations, and Manager of Care Coordination. Three of the Q-sort judges were Physicians (Medical Doctors – MDs) and all judges possessed prior clinical academic training. Upon the completion of each Q-sort exercise, inconsistencies between the judge's item placement and the researcher's expectations were identified and discussed. Judges were asked to provide reasoning for their placements and feedback to clarify ambiguous items. A thorough analysis was the conducted following each round to evaluate the disposition of ambiguous items. Consequently, items were revised, deleted, combined and disentangled when double-barreled in nature. This process enhanced construct validity, and identified items or combinations of items which were considered ambiguous or to possess 'different shades of meaning' by the respondent (Churchill,

1979). Convergent and discriminant validities were assessed using: 1) inter-judge raw agreement, 2) placement ratio, and 3) Cohen's Kappa (Moore and Benbasat, 1991). The Q-sort pilot testing produced strong evidence of convergent and discriminant validity throughout the process with final results after three rounds of raw agreement - 94.0%, overall placement ratio - 96.6%, and Kappa score - 93.6%. The judges also provided feedback supporting the relevance of the study and the appropriateness of the target respondents' domain knowledge. We next describe the theoretical basis for the constructs and their measurement items.

### *4.2 Measures*

Our measures include primary and secondary data. Vertical Integration (physician employment), IT Dissemination of Test Results, Social Interaction Ties, and Information Exchange Relationship were assessed using primary survey data, while our dependent variable, Provider-Patient Communication was measured using secondary data. Table 1 lists the constructs, construct definitions, measurement items, and literature references.

Table 1. Constructs, construct definitions, measurement items, and supporting literature.

| Construct | Definition | Measurement Items[1] | Literature |
|---|---|---|---|
| Information Technology Dissemination of Test Results (ITDR) | A hospital's healthcare delivery providers (i.e. doctors, nurses and staff) utilization of electronic health records systems for viewing clinical results (i.e. from lab and radiology).[2] | *We use EHR to view:*<br>ITDR1: lab results.<br>ITDR2: radiology reports.<br>ITDR3: diagnostic test results. | Ash et al., 2004; Cutler et al., 2005; Jha et al., 2009. |
| Social Interaction Ties | A willingness demonstrated by admitting physicians to expend efforts to work cooperatively with hospital staff. | *Our admitting/attending physicians:*<br>SIT1: exert effort to maintain our relationship.<br>SIT2: are willing to provide assistance to our staff.<br>SIT3: abide by their commitments.<br>SIT4: make an effort to work with our staff. | Nahapiet and Ghoshal, 1998; Wasko and Faraj, 2004; Carey et al., 2011; and Villena et al., 2011. |
| Information Exchange Relationship | Accurate, timely, adequate, and credible information interchange among those involved in a particular process. | *Information exchange between our admitting/attending physicians and us is:*<br>IER1: timely.<br>IER2: accurate.<br>IER3: complete.<br>IER4: adequate.<br>IER5: reliable. | Gittell et al., 2000; Doll and Torkzadeh, 1988; Delone and McLean, 2003; Lee, 1997; Metters, 1997; Li et al., 2005. |
| Provider – Patient Communication (CMS HCAHPS) | Doctors and nurses effectively providing medical information to patients. | *Percentage of patients who reported that:*<br>PPC1: their doctors "Always" communicated well.<br>PPC2: their nurses "Always" communicated well.<br>PPC3: staff "Always" explained about medicines before giving it to them. | Ammentrop et al., 2014; Russell Bennett, 2012; RTI, 2011. |
| Employed / Non-employed Physician | An 'employed physician' is a doctor who receives financial compensation from a hospital in exchange for treating patients. | Two sets of items were measured for each measurement item; one for employed physicians and a second for non-employed physicians.[3] | Schneller, 2001; Fink and Hartzell, 2010; Andrabi, 2012. |
| Teaching Status (Control) | A hospital's participation in medical student and resident education. | ☐Major Teaching Hospital<br>☐Minor Teaching Hospital<br>☐Non-teaching Hospital | Goldstein and Iossifova, 2012; Goldstein and Naor, 2005; Li and Benton, 2006; McFadden et al., 2009; Queenan et al., 2011. |

Notes:
1) Likert scales used for to measure EHR Use, Social Interaction Ties, and Information Exchange Relationship: 1-strongly disagree, 2-disagree, 3-nuetral, 4-agree, 5-strongly agree. N/A was also offered as a response choice.
2) The use of EHR to capture this type of data is prevalent in hospitals and likely to improve patient care (Jha et al., 2009). EHR use for results viewing is particularly relevant for this study because it facilitates collaboration among healthcare providers (AHRQ, 2013).
3) Respondents were asked to opine for each item with regard to their hospital's dealings with employed physicians and non-employed physicians.

### *4.2.1 Dependent variable: Provider-Patient Communication*

Two variables warrant further explanation. The dependent variable, Provider-Patient Communication, is measured as a composite of three items collected from the Center for Medicare and Medicaid Services (CMS) Hospital Consumer Assessment of Healthcare Providers and Systems (HCAHPS) survey. HCAHPS measures patients' perspectives on their care following inpatient stays at acute care facilities in the USA (see also Ding, 2014). The HCAHPS survey is administered to a random sample of patients on a continuing basis and reported to the public through a Hospital Compare website[1]. This enables analysis of a dyadic sample – paired sets with hospitals reporting on operational practices and patients reporting on outcomes. The mean of the three items was calculated to produce an aggregate measure of Provide-Patient Communication. This methodological approach is common in the OM literature and allows the researchers to avoid the use of a single item measure for the dependent variable (See Boyer et al., 2012; Goldstein and Iossifova, 2012; Queenan et al., 2011).

### *4.2.2 Moderating variable: Physician Employment*

In practice, most hospitals work with both employed and non-employed physicians (Fink and Hartzell 2010). This fact is apparent in the data we collected as only 5% of hospitals in the sample operate in closed, fully vertically integrated systems (100% physician employment). To capture our moderating variable, physician employment, each perceptual variable in the study was measured using the items mentioned previously in this section (Table 1), for employed physicians and non-employed physicians, thus creating two sets of items. This approach captures hospital-physician relationships that *are* and *are not* vertically integrated in a dichotomous sense.

[1] Additional information about the HCAHPS survey can be found at: http://www.hospitalcompare.hhs.gov/Data/PatientSurvey/Overview.aspx

In order to capture the *extent* to which a hospital is vertically integrated with the physicians providing services in the hospital, we included an item in the survey which assesses the hospital's percentage of employed physicians using the following scale: < 5%, 6%-15%, 16%-35%, 36%-65%, > 66%, but < 100%, and 100% - closed system. A literature search and practitioner expert interviews during the instrument development process indicated that a well-known and proven scale measuring the level of physician employment has not been developed. As such, given that only about 25% of physicians are employed by hospitals (75% are independent) (Bush, 2012), it was desirable to create a scale with greater sensitivity to lower percentages of employed physicians as opposed to creating equal categories (e.g., 0%-20%, 21%-40%, and so on). Table 2 displays the distribution of respondents and shows that each category is fairly well populated with the logical exception of 100% closed systems given that these remain rare. The fact that each category is fairly equally populated provides confidence that the scale ought to be useful for analysis purposes as it validates the practice-reality suggested by industry literature and the Q-sort judges who concurred with the 25% employed physician approximation.

The hospital-level measure of physician employment enables the computation of weighted composite measures accounting for the level of hospital adoption of vertical integration. Procedurally, each hospital response for each survey item (one with respect to their employed physicians, and another with respect to their non-employed physicians) was weighted based on that hospital's percent of employed physicians and summed to produce a composite score for each item.

*4.3 Data collection and demographics*

A self-administered internet survey was conducted using a sample frame created from a random list of acute care facilities in the membership of the American Hospital Association (AHA) (see Meyer and Collier, 2001; Li et al., 2002; Li and Benton, 2006 for other OM/SCM studies using the AHA). Telephone solicitation populated the sample frame with email addresses of prospective respondents (e.g. see McFadden et al., 2009). The sample consisted of 671 hospital executives from 644 AHA acute care facilities. 312 responses were received, generating a response rate of 46.5% (312/671). After screening, two of the surveys were deleted because of missing values, leaving 310 responses in the sample. Next, responses received from multiple raters from eight hospitals were averaged for each item (McFadden et al., 2009). This resulted in a final sample for analysis of 302 hospitals in 47 states in the USA. For 173 cases where the respondent identified the hospital, it is possible to locate CMS data, so $n$=173. Our final distribution of respondents is over 50% holding the titles of Director of Case Management (39 or 23%), Chief Nursing Officer (27 or 16%), or VP of Patient Care Services (27 or 16%). The balance is primarily comprised of Directors of Quality Initiatives (14 or 8%), Directors of Nursing (10 or 6%) among others such as CEOs, COOs, VPs of Medical Staff Affairs, and VPs of Case Management. Domain knowledge for professional's holding these positions was confirmed via job description review by the authors and confirmed by six judges during the pilot Q-sort stage of instrument development. Sample demographics are reported in Table 2.

Table 2. Sample characteristics (n=173).

| Characteristics | Respondents | Characteristics | Respondents |
|---|---|---|---|
| *Hospital type* | | *Size – number of beds* | |
| Tertiary care center | 38 (22%) | < 49 | 15 (9%) |
| Community hospital | 118 (68%) | 50-99 | 40 (23%) |
| Critical access hospital | 13 (8%) | 100-199 | 43 (25%) |
| Other/missing values | 4 (2%) | 200-399 | 37 (21%) |
| | | > 400 | 36 21%) |
| *Location** | | Other/missing values | 2 (1%) |
| Urban | 93 (54%) | | |
| Rural | 77 (45%) | *Teaching status* | |
| Other/missing values | 3 (2%) | Major teaching hospital | 37 (21%) |
| | | Minor teaching hospital | 53 (31%) |
| *Percentage of employed physicians* | | Nonteaching hospital | 81 (47%) |
| < 5% | 36 (21%) | Other/missing values | 2 (1%) |
| 6%-15% | 37 (21%) | | |
| 16%-35% | 22 (13%) | *Ownership status* | |
| 36%-65% | 34 (20%) | For-profit hospital | 20 (12%) |
| > 66%, but < 100% | 34 (20%) | Non-profit hospital | 131 (76%) |
| 100% - closed system | 9 (5%) | Public hospital | 18 (10%) |
| Other/missing values | 1 (1%) | Other/missing values | 4 (2%) |

* Hospitals from 46 states participated in the study.
Note: Numbers represent frequency, followed by the percentage (rounded) of the sample in parentheses.

## 5. Analysis and results

We tested for non-response bias. Non-respondent data for hospital type were gathered through internet research while bed size and system affiliation were provided by the AHA. T-tests and chi-square tests revealed no statistical differences for these variables, rejecting non-response bias (Armstrong and Overton, 1977).

### *5.1 Measurement model results*

Co-variance based Structural Equation Modeling (SEM) in AMOS was used to examine the convergent and divergent validity of variables in a confirmatory factor analysis (CFA). All constructs were modeled as reflective rather than formative. This implies that (1) each measurement item of a particular construct represents a manifestation of that construct and the direction of causality is from the construct to its facets, the items; (2) the items are interchangeable; (3) covariation among the items is not unexpected; and (4) the nomological

networks associated with the items are expected to be similar (Jarvis et al. 2003; Petter et al. 2007). Given our understanding of the healthcare operations domain, the guidance provided in the literature regarding formative versus reflective construct specification, and our statistical results, we employed a reflective approach. This is consistent with the literature as Jha et al. (2009) measured EHR use for viewing test and imaging results to include lab reports, radiology reports and images, and diagnostic test results and images, and suggested that each of these would reflect the use of IT to view results.

The correlated measurement model was tested and results are displayed in Table 3. All items show lambda (λ) values greater than 0.7 and are statistically significant on their hypothesized latent constructs indicating convergent validity (Anderson and Gerbing, 1988). An exception is SIT3 (λ=0.67 for the employed sample) which is statistically significant on its hypothesized construct and retained given its theoretical significance. All measurement model statistics are displayed in Table 3 and meet commonly acceptable thresholds for $X^2$/df, GFI, CFI, NNFI (TLI) and RMSEA (Hair et al., 2006). Each variable demonstrates acceptable composite reliability (Segars, 1997).

The datasets collected for employed and non-employed physicians were tested and produced evidence of measurement invariance (see Cao and Zhang, 2011). The procedure tests (1) the model fit of the baseline model referred to as the *totally free multiple group model* (TF), (2) a model of factor loading equivalence, and (3) a model of factor loading and inter-factor covariance (Hair et al., 2006). All three models produced acceptable fit results. In model 2, each factor loading was constrained to be equal across the groups. The $X^2$ difference between model 2 and model 1 is 14.74 with df of 11 which is not statistically significant ($p$=0.20) indicating that factor loadings are invariant across the subsamples. The $X^2$ difference between model 3 and

model 2 is 20.28 with 15 df. This is also not statistically significant ($p$=0.16) indicating that factor loadings and inter-factor correlations (phi) are invariant across the subsamples, providing adequate cross-validation (invariance) of the datasets (MacCallum et al., 1994; Hair et al., 2006).

Table 3. Measurement model statistics.

| Construct | Indicator | Loadings (λ) Emp/Non-Emp/Comp[1] | *t* value Emp/Non-Emp/Comp[1] | Reliability Emp/Non-Emp/Comp[1] |
|---|---|---|---|---|
| IT Dissemination of Test Results | ITDR1 | 0.96/0.92/0.95 | -[a] | 0.98/0.96/0.97 |
| | ITDR2 | 0.99/0.99/0.99 | 36.94/28.57/35.18 | |
| | ITDR3 | 0.95/0.93/0.95 | 29.08/22.48/27.23 | |
| Social Interaction Ties | SIT1 | 0.81/0.80/0.85 | -[a] | 0.88/0.88/0.91 |
| | SIT2 | 0.88/0.82/0.88 | 13.16/11.64/14.49 | |
| | SIT3 | 0.67/0.77/0.75 | 9.32/10.79/11.53 | |
| | SIT4 | 0.85/0.85/0.88 | 12.55/12.11/14.48 | |
| Information Exchange Relationship | IER1 | 0.88/0.86/0.88 | -[a] | 0.93/0.91/0.93 |
| | IER2 | 0.88/0.82/0.84 | 16.45/13.57/15.08 | |
| | IER3 | 0.85/0.86/0.87 | 15.27/14.76/16.01 | |
| | IER4 | 0.87/0.82/0.84 | 15.78/13.52/15.08 | |
| | IER5 | 0.84/0.85/0.87 | 14.99/14.36/15.94 | |
| Provider-Patient Communication (CMS Data) | PPC1 | 0.82/0.82/0.82 | -[a] | 0.91/0.91/0.91 |
| | PPC2 | 0.88/0.88/0.88 | 13.37/13.40/13.43 | |
| | PPC3 | 0.90/0.90/0.90 | 13.59/13.65/15.03 | |

1) Values for the employed physician sample precede values for the non-employed physician sample which are followed by values for the composite sample.
2) Model fit (unconstrained): $X^2$=252.57, d.f.=190, $X^2$/d.f.=1.33, GFI=0.92, RMSEA=0.03, CFI=0.99, NNFI=0.98
Model fit (emp): $X^2$=105.54, d.f.=95, $X^2$/d.f.=1.11, GFI=0.93, RMSEA=0.03, CFI=0.99, NNFI=0.99
Model fit (non-emp): $X^2$=147.03, d.f.=95, $X^2$/d.f.=1.55, GFI=0.91, RMSEA=0.06, CFI=0.98, NNFI=0.97
Model fit (composites): $X^2$=142.38, d.f.=95, $X^2$/d.f.=1.50, GFI=0.91, RMSEA=0.05, CFI=0.98, NNFI=0.97
3) Models were tested for measurement invariance and shown to be invariant.
4) [a] Fixed parameter.

Convergent and discriminant validities have been verified by examining the average variance extracted (AVE) and correlations among the variables (Fornell and Larcker, 1981; Koufteros et al., 2001). See Tables 4a, 4b, and 4c. All correlations are below the 0.90 cutoff as a measure of collinearity suggested by (Hair et al., 2006). Further, tolerance and variance inflation factor (VIF) tests for multicollinearity were performed and all produced results within acceptable ranges (Hair et al., 2006). All Cronbach's α values are acceptable. Finally, our methodological approach employing a pair (primary and secondary) dataset mitigates the threat of common

method bias (CMB) (Boyer et al., 2012; Boyer and Swink, 2008). However, as a precaution, procedural remedies were used following Rosenzweig (2009) when preparing the survey and subsequent statistical tests using a methods factor refuted CMB (Podsakoff et al., 2003).

Table 4a. Variable descriptive statistics, Cronbach's α, average variance extracted (AVE), and correlations for items dealing with **employed physicians**.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **1. IT Dissemination of Test Results** | **.93/.97** | | | | |
| μ = 4.70; σ = 0.51; α = 0.98 | | | | | |
| **2. Social Interaction Ties** | .217 | **.65/.81** | | | |
| μ = 4.33; σ = 0.55; α = 0.87 | | | | | |
| **3. Information Exchange Relationship** | .135 | .586 | **.75/86** | | |
| μ = 3.99; σ = 0.63; α = 0.93 | | | | | |
| **4. Provider-Patient Communication** | .026 | -.021 | .126 | **.75/.87** | |
| μ = 72.18; σ = 4.33; α = 0.90 | | | | | |
| 5. Teaching Status | .073 | .060 | -.001 | -.172 | -- |
| μ = 0.74; σ = 0.79 | | | | | |

1. The AVE for each variable is shown on the diagonal immediately followed by the square root of the AVE for discriminant validity testing.
2. Teaching Status is a categorical variable used as a control.
3. Correlations > 0.216 are significant at $p < 0.01$; correlations < -0.171 are significant at $p < 0.05$.

Table 4b. Variable descriptive statistics, average variance extracted (AVE), and correlations for items dealing with **non-employed physicians**.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **1. IT Dissemination of Test Results** | **.90/.95** | | | | |
| μ = 4.68; σ = 0.49; α = 0.97 | | | | | |
| **2. Social Interaction Ties** | .058 | **.66/.81** | | | |
| μ = 3.66; σ = 0.75; α = 0.88 | | | | | |
| **3. Information Exchange Relationship** | .047 | .521 | **.71/.84** | | |
| μ = 3.61; σ = 0.70; α = 0.92 | | | | | |
| **4. Provider-Patient Communication** | .007 | -.007 | .185 | **.75/.87** | |
| μ = 72.18; σ = 4.33; α = 0.90 | | | | | |
| 5. Teaching Status | .025 | .056 | .033 | -.173 | -- |
| μ = 0.74; σ = 0.79 | | | | | |

1. The AVE for each variable is shown on the diagonal immediately followed by the square root of the AVE for discriminant validity testing.
2. Teaching Status is a categorical variable used as a control.
3. Correlations > 0.520 are significant at $p < 0.01$; correlations < -0.172 are significant at $p < 0.05$.

Table 4c. Variable descriptive statistics, average variance extracted (AVE), and correlations for items dealing with **weighted composite variables (employed and non-employed physicians)**.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **1. IT Dissemination of Test Results** | **.93/.96** | | | | |
| μ = 4.70; σ = 0.50; α = 0.97 | | | | | |
| **2. Social Interaction Ties** | .097 | **.71/.84** | | | |
| μ = 3.91; σ = 0.70; α = 0.90 | | | | | |
| **3. Information Exchange Relationship** | .049 | .563 | **.74/.86** | | |
| μ = 3.74; σ = 0.69; α = 0.93 | | | | | |
| **4. Provider-Patient Communication** | .006 | .075 | .240 | **.75/.87** | |
| μ = 72.18; σ = 4.33; α = 0.90 | | | | | |
| 5. Teaching Status | 0.71 | .093 | .045 | -.173 | -- |
| μ = 0.74; σ = 0.79 | | | | | |

1. The AVE for each variable is shown on the diagonal immediately followed by the square root of the AVE for discriminant validity testing.
2. Teaching Status is a categorical variable used as a control.
3. Correlations > 0.239 are significant at $p < 0.01$; correlations < -0.172 are significant at $p < 0.05$.

### *5.2 Structural model results*

The results from the structural model are displayed in Table 5 and Figure 2. Our analysis of two datasets collected for employed and non-employed physician dealings enables us to examine the moderating role of vertical integration in hospitals. The weighted composite dataset enables us to examine how hospitals manage a mixed employed / non-employed physician operational environment which is common in practice (Bush, 2012). Model fit statistics for all datasets meet commonly accepted thresholds. Hypothesis 1 linking Information Exchange Relationship to Provider-Patient Communication and hypothesis 2 linking Social Interaction Ties and Information Exchange Relationship are both supported in all of the datasets. These results reveal that while Social Interaction Ties does not have a significant direct effect on Provider-Patient Communication (in fact the direct effect is non-significant and negative), Social Interaction Ties does influence Provider-Patient Communication indirectly through Information Exchange Relationship. It should be noted that H1 in the employed physician dataset is marginally significant ($\beta$=0.20, t=1.92, $p$=0.055). This may indicate that as vertical integration (i.e. physician employment) increases, providers may take more initiative to communicate with

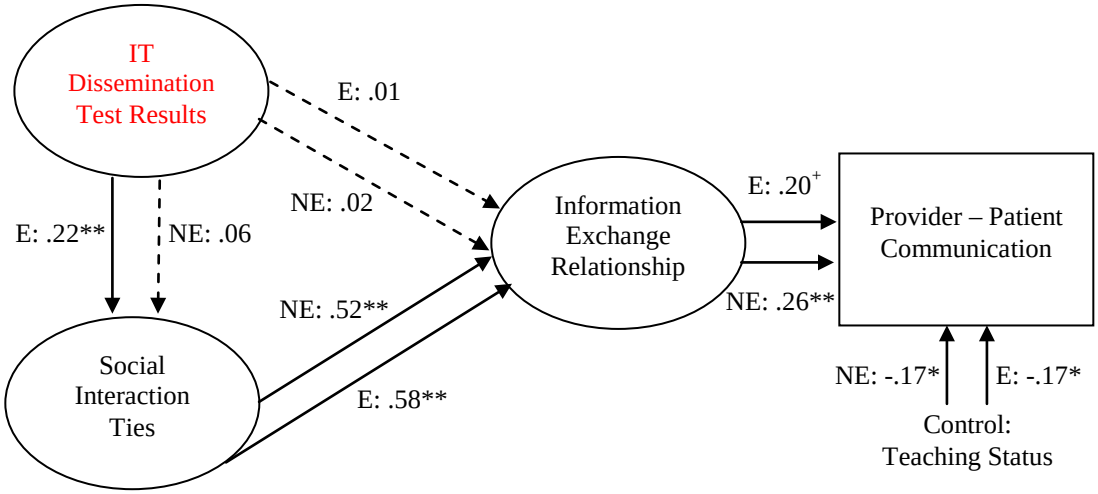
patients regardless of the strength of the information exchange relationship among physicians and the hospital staff.

Table 5. SEM results for direct and indirect effects

| Hypothesis | Employed Physicians | | | Non-employed Physicians | | | Weighted Composite Variables | | |
|---|---|---|---|---|---|---|---|---|---|
| | Direct effect | T-stat | Indirect effect | Direct effect | T-stat | Indirect effect | Direct effect | T-Stat | Indirect effect |
| H1: Info Exch Rel → Prov-Pt Com | .20+ | 1.92 | -- | .26** | 2.63 | -- | .29** | 2.86 | -- |
| H2: Social Int Ties → Info Exch Rel | .58** | 7.15 | -- | .52** | 6.28 | -- | .56** | 7.21 | -- |
| H3: IT Test Results → Info Exch Rel | .01 | 0.12 | .13** | .02 | 0.25 | .03 | -.01 | -0.09 | .06 |
| H4: IT Test Results → Social Int Ties | .22** | 2.71 | -- | .06 | 0.72 | -- | .10 | 1.22 | -- |
| IT Test Results → Prov-Pt Com | .04 | 0.51 | .00 | .01 | 0.09 | .01 | .01 | 0.15 | .01 |
| Social Int Ties → Prov-Pt Com | -.14 | -1.27 | .12** | -.13 | -1.33 | .14** | -.07 | -0.71 | .16** |

Model fit (emp): $X^2$=107.03, d.f.=98, $X^2$/d.f.=1.09, GFI=0.93, RMSEA=0.02, CFI=0.99, NNFI=0.99
Model fit (non-emp): $X^2$=147.61, d.f.=98, $X^2$/d.f.=1.51, GFI=0.91, RMSEA=0.05, CFI=0.98, NNFI=0.97
Model fit (composite): $X^2$=144.42, d.f.=98, $X^2$/d.f.=1.47, GFI=0.91, RMSEA=0.05, CFI=0.98, NNFI=0.98
**$p < 0.01$; *$p < 0.05$; +$p < 0.10$

Figure 2. Path model results.




**$p < 0.01$; *$p < 0.05$; +$p < 0.10$
Solid lines: Statistically significant · Dashed lines: Not statistically significant
E: Employed Physicians · NE: Non-Employed Physicians

Hypothesis 3 linking IT Dissemination of Test Results and Information Exchange Relationship is not supported in any of the datasets. As such, hypothesis 5a testing the moderating effect of vertical integration is not supported. The effect of IT Dissemination of Test Results on Information Exchange Relationship is indirect (coefficient=0.13, $p$<0.01), mediated

by Social Interaction Ties for employed physicians, while this indirect effect is not significant in the non-employed, nor weighted composite data. This indicates that IT Dissemination of Test Results improves Information Exchange Relationship indirectly through Social Interaction Ties when the hospital vertically integrates with physicians. Hypothesis 4 linking IT Dissemination of Test Results and Social Interaction Ties is supported in the employed physician data, however this relationship is not significant in the non-employed physician, nor weighted average data. These results support hypothesis 5b suggesting that vertical integration moderates (amplifies) the link between IT Dissemination of Test Results and Social Interaction Ties.

Finally, Teaching Status was included in the model as a control variable linked to Provider-Patient Communication. The literature commonly hypothesizes (but often fails to support) that teaching hospitals perform differently than non-teaching hospitals given their application of research, teaching, and cutting–edge approaches to care (Goldstein and Naor, 2005; McFadden et al., 2009). Our analysis links Teaching Status to Provider-Patient Communication and shows that it negatively influences Provider-Patient Communication in the employed physician data ($\gamma$=-0.17, $p$<0.05), the non-employed physician data ($\gamma$=-0.17, $p$<0.05), and of course, the weighted composite data ($\gamma$=-0.18, $p$<0.05).

*5.3 Sensitivity testing*

The results from our weighted composite dataset, a strong Information Exchange Relationship improves Provider-Patient Communication, and a strong Information Exchange Relationship results from Social Interaction Ties among the hospital and medical staff. However, IT Dissemination of Test Results fails to motivate neither an Information Exchange Relationship, nor Social Interaction Ties at the level of employment in our sample (mean response is 2.12 or 16-35%). Our sample mean for employment is consistent with industry literature which estimates

that approximately 25% of physicians in the U.S. are employed by a hospital (Bush, 2012). Given that IT Dissemination of Test Results generates Social Interaction Ties when physicians are employed, a natural question is *at what level of employment can hospital achieve the link between IT Dissemination of Test Results and Social Interaction Ties?* To inform this question, we ran a sensitivity analysis and determined that the employment level at which hypothesis 4 becomes statistically significant is 67% employed (33% non-employed physicians). At 67% employment, Information Exchange Relationship is significant on Provider-Patient Communication (H1: $\beta$=0.25, $p$=0.02), Social Interaction Ties is significant on Information Exchange Relationship (H2: $\beta$=0.57, $p$=.00), and IT Dissemination of Test Results is significant on Social Interaction Ties (H4: $\beta$=0.16, $p$=.05).

## 6. Discussion

We set out to understand key factors involved in achieving information exchange in healthcare delivery operations. Reflecting on our results, we identify the following as contributions to theory and practice.

### *6.1. Contributions to Theory*

First, we establish information exchange based coordination as a precursor to patient perceptions of their communication with healthcare providers. In particular, we show that provider-patient communication can be enhanced by improved coordination in the form of information exchange relationships among healthcare providers (i.e. physicians and staff) in a hospital. This provides a potential theoretical argument to examine and address the operational problems of interdependencies and fragmentation inherent in healthcare delivery processes. While the literature has highlighted the importance and absence of coordination among different individual providers in the healthcare delivery process as critical to satisfactory clinical outcomes

(Boyer and Pronovost, 2010; Gittel and Weiss, 2004, Fredendall et al., 2009), it does not explain the operational activities embodied in such coordination. Our results show that ongoing exchange of timely, accurate and reliable information among healthcare providers (e.g. doctors, nurses and technicians) constitutes information exchange based coordination and is associated with superior performance. Furthermore, the relationship between social interaction ties and provider-patient communication is fully mediated by information exchange relationship, reinforcing the notion that achieving desirable patient outcomes requires coordination among individuals, possibly over and above any single individual's effort.

Secondly, and counter intuitively, we find a *fully* mediating role for social interaction ties in the relationship between IT dissemination of test results and information exchange (in the employed physician data). This illuminates the difficulties in achieving information exchange based coordination *solely through use of IT*. We find that IT dissemination of test results is not a direct antecedent of information exchange, but that higher levels of IT dissemination of test results are associated with higher levels of information exchange indirectly, through the fully mediating effect of social interaction ties. This points to complementarity between the technical (i.e. IT dissemination of test results) and the social (i.e. social interaction among healthcare providers) aspects as essential for information exchange, such that they act *in tandem* to boost the latter. While adoption of IT by hospitals and its use by healthcare providers is a useful first step, by itself it does not necessarily lead to beneficial outcomes vis-à-vis information exchange, which is critical to superior patient outcomes. From the operations perspective, this suggests that the activities of IT implementation and use by physicians, nurses and technical staff should be *accompanied by* corresponding activities of social interaction and relationship-building among them to promote information exchange processes.

Third then, we come to the role of social interaction ties. While teamwork is important in achieving performance in healthcare delivery, it is not necessarily common (Boyer and Pronovost, 2010). This is at least in part driven by the autonomy and loyalty to the profession on part of physicians (Fredendall et al., 2009; Schneller and Smeltzer, 2006). We note that strong interaction ties can be useful in overcoming differentiation borne out of deep clinical specialization (Nembhard et al., 2009). This places social interaction in two key positions. One, as an antecedent of information exchange and two, as a complement to IT use in facilitating information exchange. The theoretical significance of this finding lies in considering strong social interaction ties as an important structural element for appropriating coordination from IT use by healthcare providers in the hospital operations context.

Fourth, we show that vertical integration (in the form of physician employment) enhances the extent to which IT dissemination of test results by physicians and staff leads to social interaction ties and information exchange based coordination among physicians and staff. This finding is theoretically important because it shows that vertical integration can enhance benefits from use of *internal* IS. Typically, vertical integration, has been considered in the context of adoption of *inter-organizational* IT. Healthcare operations have the distinctive characteristic that *external* partners (i.e., physicians) use *internal* IT (i.e., EHR). We show that the more the partners are employed or 'internal', that is more the vertical integration, the greater the benefits from use of internal IT. We thus demonstrate the importance of vertical integration in appropriating benefits from use of *internal* IS, in this case IT dissemination of test results. While we traditionally know that vertical integration might suppress the benefits from inter-organizational IS (e.g., Xue et al 2013), our study shows that it also *boosts* the benefits from the use of internal IS.

Finally, we note the absence of a direct significant relationship between IT dissemination of test results and the dependent variable of provider–patient communication. The theoretical and contextual significance of this finding is the notion that given the particulars of healthcare delivery operations, the use of IT may not be associated with superior outcomes for patients unless appropriate structural (i.e. increased social interaction ties among physicians and the hospital, and physician employment) and operational (information exchange based coordination) factors are present. We thus identify possible conditions *when* IT dissemination of test results would lead to specific benefits, a theoretical extension to existing studies on EHR use (e.g. Devaraj et al., 2013; Queenan et al., 2011).

In sum, we address the problem of information exchange and coordination difficulty in healthcare delivery operations by theorizing relationships among variables that embody a match between contextual realities and key theoretical concepts in operations. In doing so, we propose and validate a set of relationships that future research examining coordination where *independent* parties are called upon to execute *inter-dependent* tasks toward a common objective, can draw on. Such a situation is becoming increasingly common in a number of operational domains such as higher education, legal, financial, and reverse supply chains; domains where process-oriented IT is deployed to facilitate interaction among dispersed organizational members/providers engaged in value co-creation (Schmenner et al., 2009).

*6.2. Implications for Practice*

A recent American College of Healthcare Executives survey (ACHE, 2013) revealed three key issues facing hospital executives as (1) reimbursement methods reflecting patient perceptions of their care, (2) technology, and (3) physician-hospital relations. From the point of

view of managerial recommendations, our study provides important insights on how to tackle each of these issues as we describe below.

To begin, reimbursement to hospitals by insurance companies and CMS now increasingly depends upon the extent to which desired *patient outcomes* are achieved (Russell Bennett, 2012; Ding, 2014) since patients are the end consumer of healthcare delivery processes and the ultimate judges of value (Schneller and Smeltzer, 2006; Salzarulo et al., 2011). Specifically, for hospitals operating under the CMS Inpatient Prospective Payment System[2], the HCAHPS measures analyzed in this study will affect hospital reimbursement levels. Therefore achieving high HCAHPS scores is critical. Our study provides two recommendations to healthcare executives on how this can be achieved. Firstly, an information exchange relationship among hospital staff and physicians that provides for timely, accurate, adequate, complete, and reliable information sharing will improve the hospital's HCAHPS scores. Healthcare executives ought to emphasize these behaviors among the hospital staff and also consider the potential of proactively establishing an information exchange relationship with those physicians targeted for recruitment or practice acquisition. Secondly, considering that social interaction ties can (indirectly) increase HCAHPS, hospital executives should foster potential employment-oriented relationships with those physicians who are oriented towards high levels of social interaction, that is, who exert effort to maintain a relationship with the hospital, provide assistance to the hospital staff, abide by their commitments, and genuinely make an effort to work with the staff. These strategies have the potential to improve patient satisfaction measured via HCAHPS scores and thus can improve financial performance. We further show that executives leading *teaching hospitals* ought to be *particularly* interested in these findings given that teaching status is statistically significant and

[2] See: http://www.hcahpsonline.org/executive_insight/

negative when linked to our HCAHPS variable. This indicates the importance of improving provider-patient communication through a high quality information exchange relationship and strong social interaction ties among hospital staff and physicians in teaching hospitals.

Secondly, EHR technology implementation has proven thorny for healthcare executives because it does not often result in explicit benefits to the hospital (Goh et al., 2011). Perhaps the apparent ambiguity regarding how healthcare providers can *practically* translate EHR use into improved performance has contributed to the slow adoption of such technologies aimed at coordinating healthcare delivery (Ilie et al., 2009). However, IT adoption is expected to increase substantially given recent U.S. federal *investment* and legislative changes *incentivizing* 'meaningful use' of EHR by healthcare providers (Queenan et al., 2011). This study provides healthcare practitioners a glimpse of what meaningful use might be in practice. In terms of managerial recommendations, we suggest that hospitals can extract value from IT dissemination of test results by emphasizing the role of social interaction ties in translating IT use into improved information exchange (Buell, 2013). Up until now, increasing the *extent of use of EHR* by physicians and hospital staff has been the primary focus in EHR implementations. We show that this is perhaps not enough, in that IT dissemination of test results is not directly related to improved patient outcomes. Providers in the healthcare delivery process need to be sensitized to the idea that *augmenting* IT use with timely, accurate and consistent information exchange among physicians and staff, and strong social interaction ties among physicians and the hospital, are what enable superior patient outcomes. Our findings are timely and consistent with patient care issues surrounding the Ebola threat. Recently, Dr. Daniel Varga, the chief clinical officer of Texas Health Resources (THR) and Texas Health Presbyterian Hospital, testified to the House Energy and Commerce Committee that he was "deeply sorry" for how the hospital handled the

treatment of the first Ebola case in the United States. The hospital initially blamed their EHR system, claiming it prevented doctors from seeing the patient's travel history, which in turn led to the patient's discharge from the hospital. Subsequently, the hospital stated that the EHR was not to blame and instead cited a miscommunication among members of patient's care team which led to the lowering of his risk status and discharge (The Advisory Board Company, 2014).

Third, hospital executives have long questioned the benefits of employing physicians (Schneller, 2001) and the curiosity continues to the present (Andrabi, 2012). To speak to this, we show that physician employment can enhance hospital operations by strengthening the link between IT use and social interaction ties, which ultimately improves information exchange and HCAHPS scores. This finding is of practical value to hospital operations managers because it shows a link between physician employment and day-to-day healthcare delivery operations. Existing studies have not examined this link. Our finding of the inflection point of 67% as the level at which the relationship between IT use and social interaction ties becomes significant will be of interest to top hospital leaders responsible for operations or developing physician recruitment strategy.

*6.3. Future Research and Limitations*

While our study makes important contributions, we acknowledge several limitations and highlight counter measures where possible in our study. As is the case with most survey research, the results represent a cross-sectional snapshot in time and lack the ability to provide deep insights into the motivations of individual participants as is possible with ethnographic methods. Likewise, all data were collected from a single industry – USA acute care hospitals. While this is consistent with similar studies (see Boyer et al., 2012; Gowen et al., 2006; Meyer and Collier, 2001; Li et al., 2002; Li and Benton, 2006), it may limit generalizability. Next, while

we set out to measure IT use in hospitals, other valuable measures such as IT maturity (e.g., the HIMSS survey) also represent useful conceptualization worthy of examination. Finally, while our instrument performed satisfactorily, we did not statistically test the scales in a pilot study. As such, future research replicating this study would be useful. Despite these potential limitations, the study does provide meaningful insights addressing key challenges that hospitals face at the intersection of three key issues – coordination in health care processes, use of IT, and physician employment.

Teaching status has a negative effect on provider-patient communication, building upon Queenan et al. (2011) who found that the influence of Computerized Physician Order Entry systems on patient satisfaction is stronger in non-academic hospitals. It is possible that teaching hospitals may be challenged to effectively communicate with patients given their additional requirements for teaching and research (Li and Benton, 2006). In addition, patients may be intimidated by large medical teams consisting of the attending physician, residents and medical students and thus could be distracted when receiving important information about their condition such as discharge instructions. Future research may seek to further explore this finding. Examining other mediators that exist in the pathway from EHR use to patient experiences forms another possibility for future research that explain the heterogeneity that exists in seemingly isomorphic hospital operational practices (Bhakoo and Choi, 2013). Finally, while this research addresses problems related to coordination, social interaction ties, and vertical integration characterizing healthcare delivery operations, future studies should explore these problems in other aspects of healthcare operations that improve patient care such as process improvement.

## 7. Conclusion

Our study responds to recent calls to apply operations management to improve the work of physicians and hospitals (Boyer and Pronovost, 2010; Dobrzykowski et al., 2014). Specifically, we draw from concepts on information exchange, co-ordination and social ties to highlight the difficulties in achieving information exchange based coordination and positive patient perceptions of their care solely through the use of IT. In doing so, we theoretically investigate the somewhat intractable EHR – patient outcomes black box. We also provide useful insights into three current issues facing healthcare executives related to – improving patient perceptions of their care, technology use, and physician-hospital relations (ACHE, 2013).

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