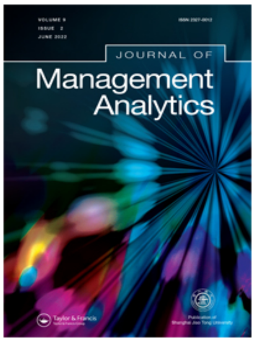

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Impact of hospital size on healthcare information system effectiveness: evidence from healthcare data analytics

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With the rapid development of information technology, the increasing use of mobile digital devices and efforts from the whole society, the healthcare information systems (HISs) are moving towards a new era. However, there is still a lack of clear understanding of the benefits of HIS at the hospital level and the influential factors for HIS effectiveness. In this study, we propose a research framework to explain how HIS implementation improves hospital performance. Our results reinforce the positive effect of HIS on hospital performance. In particular, we found that HIS implementation increases both the cost and revenue of the hospitals, but the increasing effect in revenue is much bigger than the increasing effect in cost. We also found that although both small and big hospitals benefit from the implementation of HIS, the effect of size is different. Size has a positive effect on hospital performance for small hospitals but has a negative effect on big hospitals. This indicates that the competitive advantage of economies of scale disappears for big hospitals because the level of information transparency becomes lower and transaction costs become higher as size increases.

Keywords: healthcare; healthcare information systems; HIS; hospital performance; size

1. Introduction

Healthcare information systems (HISs), sometimes referred to as "health care systems" or "health systems," are computerized systems that facilitate information sharing and processing within and across healthcare facilities. The healthcare sector in the United States has been criticized for a long time for its high cost and low efficiency (Kane, 2012). The deployment of HISs can potentially streamline clinical processes, facilitate the sharing of patient information, reduce healthcare costs and improve overall quality (Ayal & Seidmann, 2009; Khoumbati et al., 2006).

There are many types of HISs that function in different aspects of healthcare operations. Electronic medical record (EMR) is used to store electronic medical information generated during the process of diagnosis. EMR is designed according to the diagnosis process in the medical facility and rarely extended outside the scope of a

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hospital, clinic, or medical center. Electronic health record (EHR) is the systematic collection of electronic health information about patients, which can go beyond the scope of a single medical facility. EHR integrates information across different facilities and systems, and EMR can serve as a type of data source for the EHR (Habib, 2010; Kierkegaard, 2011). An important component of EHR is the Continuum of Care Document (CCD), which is a healthcare standard for sharing and exchanging patient data across organizations. According to the Healthcare Information and Management Systems Society (HIMSS), the adoption of HISs lags far behind that in other industries in the country. Abelson and Creswell (2014) reported that only 44 percent of all institutions have adopted basic electronic systems necessary for properly coordinating patient care. A large fraction of healthcare providers only implemented a clinical data repository system – the most basic component of the EHR system, but have not yet implemented other useful HISs such as computerized practitioner order entry (CPOE) or a clinical decision support system.

HISs are fundamentally different from industrial and consumer products which are concerned about market share protection (Mandl & Kohane, 2012). Even though many studies have been conducted over the past two decades to examine the adoption and use of information systems, there is still a lack of clear understanding of the benefits of HIS at the hospital level, and the influential factors for HIS effectiveness. In this study, we use the data provided by the HIMSS to empirically examine the impact of HIS implementation on hospital performance. In particular, we ask the following questions: Does the implementation of HIS improve hospital performance? If so, what is the mechanism allowing HIS to influence the hospital's performance? Does the influence of HIS differ for big hospitals and small hospitals, if so why?

2. Theoretical background

2.1. *Design and implementation of HIS*

Evaluating, designing and implementing HISs cover a wide scope. HIS implementation requires the integration of technology factors (e.g. information integration and knowledge management) and social factors (e.g. management, psychology, and policy). This multidisciplinary research has drawn interests from many fields including information systems, computer science, business management, medical science and others. Wilton and Mccoy (1989) introduced a distributed database that established data links between different applications running in a local network (Wilton & Mccoy, 1989). Both patient information and reference materials were included in their database. Lamoreaux (1996) described a database architecture in a medical center in Virginia that integrated the patient treatment file, outpatient clinic file and fee basis file altogether (Lamoreaux, 1996). Johnson et al. (1997) discussed the generic database design for patient management information (Johnson et al., 1997) and indicated that the database design needed to allow efficient access to clinical management events from a patient, even, location, and provider. Tsumoto (2000) developed a rule instruction system to automatically discover the knowledge from an outpatient healthcare system (Tsumoto, 2000), similar to Khoo et al. (2000)'s knowledge extraction and discovery system while using the graphical pattern of a medical database (Khoo et al., 2000). Chandrashekar et al. (2006) talked about the considerations when designing a reusable medical database, including the contract issue between the clinical applications and the storage component, multi-modality support, centralizing external dependencies, communication models, and performance considerations (Chandrashekar et al., 2006). Xu et al. (2011) introduced an integrated medical supply information system that integrated the demand, service provided, healthcare service provider's information, inventory storage data and support tools altogether (Xu et al., 2011). A recent study by Honglin et al. proposed a multiple factor integration method to calculate the similarity map for sentence aligning for a medical database (Wu et al., 2013).

2.2. Institutional theory on healthcare

The institutional theory describes how institutions are created, maintained, changed, and dissolved. It examines the environment with "positions, policies, programs, and procedures of modern organizations" (Meyer & Rowan, 1977). The intuitional theory has been applied in the field of healthcare previously (Blair et al., 2001; Covaleski et al., 1993; Dacin et al., 2002; Jensen et al., 2009; Scott, 2000; Shoib et al., 2009). According to institutional theory, the institutional environment can significantly influence the development of the adoption of new structures in an organization, often more than other outside pressures, such as market pressure (Tolbert & Zucker, 1983). A hospital is more likely to receive regulation pressure (i.e. mandating EMR adoption) from the states or the government but not from market pressure because laws and mandated regulations are "at least in part endogenous, constructed in and through the organizational fields that it seeks to regulate" (Edelman et al., 1999; Scott, 2008). With the help of the institutional theory, IT studies can retain a more systematic understanding of how technologies are embedded in the complex social environment. Zinn et al examined the influential factors to nursing home's Total Quality Management using institutional theory and resource dependence (1998). Lowe studied a large public hospital in the central North Island, New Zealand, and reported the changes caused by the implementation of a sophisticated system of case-mix budgeting, including the changes in working practices and those during clinical procedures (LOWE, 2000). Jensen et al. did a case study about the implementation of an Electronic Patient Record (EPR) system in a clinical setting (Jensen et al., 2009). As an example of process-orientated research, they examined how an EPR system traveled from the organizational field to individual doctors using an institutional theory together with sense-making theory. Detailed exploration was given to doctors' experiences and their reactions to the EPR implementation. Another example of process-oriented research is Currie and Guah's 4-year study on the UK National Health Service (NHS) program (2007), in which interpretations were given based on historical and empirical data from six NHS organizations. In summary, an institutional theory is a suitable tool to explain the process and outcomes of HIS implementation. Through the lens of institutional theory, we can examine the changes in hospital performance in the complex social environment.

2.3. *Measurement of HIS outcome*

Owing to the complexity of healthcare systems, there are various measurements that implicate the system's performance. Purbey et al. adopted Beamon's evaluation criteria for supply chain performance (Beamon, 1999) and proposed a set of measurement characteristics for healthcare processes: inclusiveness, universality, measurability, consistency, and applicability (Purbey et al., 2007). Van Peursem et al. used three measurements that groups are included for health management performance: (1) Economy, efficiency and effectiveness; (2) Quality of care and (3) Process (1995). These measurement aspects focused on the quality of management and not the quality of medical practice. The first aspect mentioned here (economy, efficiency and effectiveness) is normally referred to as the three e's, and it has been devised for public sector organizations (Brignall & Modell, 2000; Mayston, 1985; Midwinter, 1994). A PMS for HIS/HIT can also be classified as financial or non-financial (Micheli & Kennerley, 2005; Schur et al., 1994; Van Peursem et al., 1995). Table 1 summarizes the studies on healthcare system performance and their measurements according to financial and non-financial categories:

In this study, we focus on financial measurement. In particular, we measure the performance of HIS from two perspectives: cost and revenue of the hospital implementing the HISs.

3. Research framework

The information system success model proposed by Delone and Mclean (2002) has been widely used to examine the effectiveness of information systems adoption. The information system success model consists of six correlated instruments describing the dynamic process within an information system. Lau et al. reviewed studies

Table 1. Healthcare system studies with financial and non-financial measurements.

Financial measurement	Non-financial measurement
- Return on investment (ROI) (Menachemi et al., 2005) - Medicaid inpatient revenue (Ginn & Lee, 2005) - Total income/revenue (Akashi et al., 2004) - Cost, market share grow, return on assets (ROA), ROI, operating profit (Li et al., 2003) - ROA, operating margin, market share, sales growth, current ratio, debt ratio, cash flow to debt ratio, cumulative depreciation ratio (Je'McCracken et al., 2001) - Net operating revenue, market share, total margin, total revenue (Lamont et al., 1993) - ROA, operating margin, net cash flow, adjusted net patient revenue (Wang et al., 2001)	- Patient satisfaction (Boulding et al., 2011; Carr-Hill, 1992; Pascoe, 1983; Press et al., 1991) - Patient safety (Bill Binglong Wang et al., 2001) - For three clinical areas: hip/knee surgery, cardiac care, and obstetric care, hospitals were rated as better than expected (fewer deaths/complications), as expected. (Hibbard et al., 2005) - Standardized mortality ratio (SMR) (Jarman et al., 2010; Kahn et al., 2007; Molyneux et al., 2009; Shortell & LoGerfo, 1981) - Bed Occupancy Rate (BOR) (Akashi et al., 2004) Mortality, readmission, and complication (DesHarnais et al., 1990) - Percent occupancy (Lamont et al., 1993)

related to health information systems, and categorized the six instruments into three layers: the first layer is the information system (IS) quality which includes system quality, information quality and service quality. The second layer is the IS use which is measured by system use and user satisfaction. The third layer is net benefits of IS implementation. Three dimensions are included for net benefits: care quality, productivity, and access. Based on the framework of DeLone and McLean and Lau et al, we propose our research framework as in Figure 1. We define the level of IT implementation as the first layer, which represents the functionality and quality of HIS that has been implemented. According to the review of Lau et al., 25 of 26 studies used the functionality of the systems to indicate HIS quality. Examples of functionality include the implementation of CPOE (Ammenwerth et al., 2008). and the adoption of EMR and EHR (Hsiao et al., 2009). In this study, we consider three functionalities: whether the physicians are mandated to utilize a CPOE system; whether the hospital uses HL7 CCD transactions to share patient data with other organizations and the percentage of EMP utilization (EMRP, Electronic Medical Record Percentage).

The second layer is service volume, which represents the amount of work carried by the hospitals. This variable captures how intensely the HIS is operated by the hospitals. Service volume is measured from four perspectives: AHA admissions, outpatient visits (NoOp), discharges (Disch) and the number of patient days (PatD). AHA admissions are the number of admissions including the number of adults and pediatric admissions (excluding births). This number includes all patients admitted during a 12-month period, including neonatal and swing admissions; outpatient

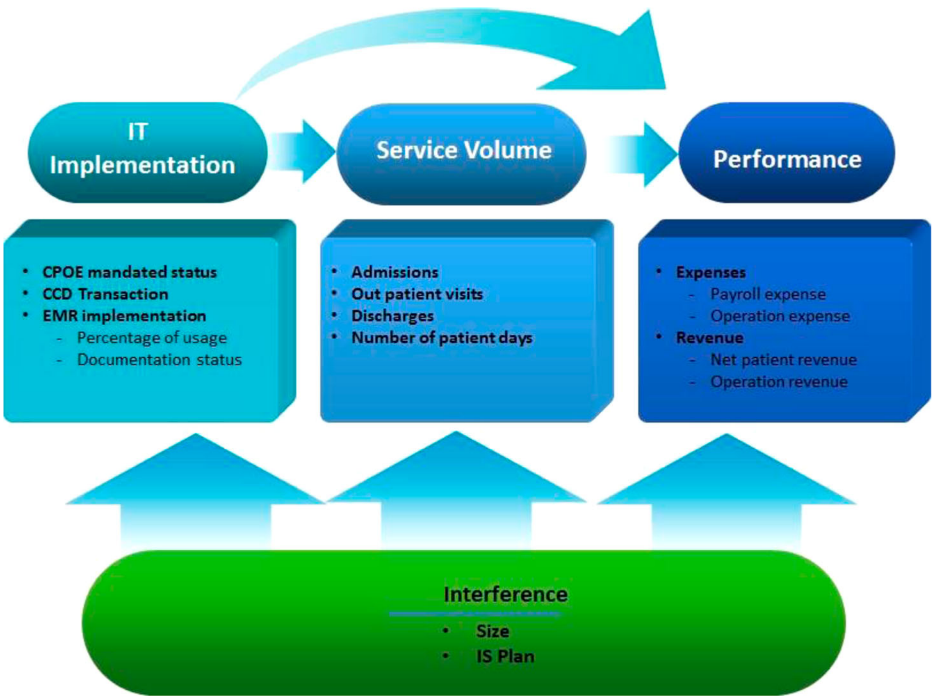

Figure 1. HIS evaluation framework.

visits (NoOp) is the number of outpatient visits at each acute-care hospital in the most recent fiscal year; discharges (Disch) are the total number of patients discharged from the hospital in a calendar year; and the number of patient days (PatD) is the number of calendar days of care provided for hospital inpatient treatment under the terms of the patient's health plan, excluding the day of discharge.

The third layer is performance, which represents the net benefits associated with the implementation of HIS. Performance is measured by both cost and revenue of the hospital implementing the HIS. Cost is measured by payroll expenses and operating expenses. Revenue is measured by net patient revenue and operating revenue.

3.1. Hypothesis development

Based on the information system success model and institutional theory, we propose the following hypotheses.

> H1: The level of IT *implementation* positively affects *service volume.*
> H2: *Service volume* positively affects hospital *performance.*
> H3: The level of *IT implementation* positively affects hospital *performance.*

The impact of IT implementation on organization performance has been widely studied. According to Lau et al. (2010), IT implementation has a positive relationship with IT utilization, and IT utilization is the mediator between IT implementation and performance. However, it is not conclusive in the context of healthcare information technology and HIS. In this study, we focus on three types of functionalities: CPOE, CCD, and EMRP. We examine the level of HIS implementation on hospital performance.

> H4: Hospital size moderates the relationship among *IT implementation*, *service volume* and *performance.*

Based on the institution theory, the operational status and profitable status of big and small hospitals may differ. Big hospitals are more standardized in terms of their management, regulations, operations and performance, whereas small hospitals are less concentrated and more flexible. Smaller hospitals have more flexible regulations and less standardized operations, which leads to more variability in their performance. Therefore, we propose that hospital size is an important factor that could influence the effectiveness of HIS implementation. We test the moderating effect of size by examining the relationships between size and service volume, size and performance, and size and IT implementation. Only when size is significantly related to both the service volume/IT implementation and performance at the same time, we conclude that size is a moderator of service volume/IT implementation.

> H5: The extent of *IS Plan* moderates the relationship among IT *implementation*, *service volume* and *performance.*

Before the implementation of HIS, some hospitals would set up clear and comprehensive plans in order to solve particular problems, such as reducing medical errors,

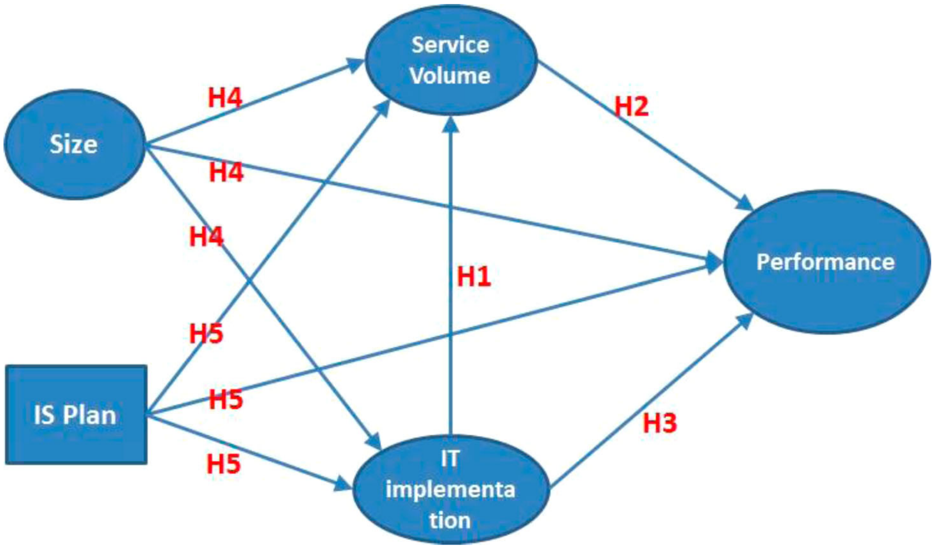

Figure 2. Testing framework for hypotheses.

reducing the number of software vendors and switching toward a paperless environment. Other hospitals do not have plans and only implement the systems for compliance with government regulations. Little work has been carried out to study the influence of hospital efforts in planning the use of HIS. In this study, we test the influence of IS plan as a moderator for the relationship among IT implementation, service volume and performance. The testing framework and hypotheses are illustrated in Figure 2.

4. Data set and variables

The HIMSS is a nonprofit organization in existence since 1961. The main goal of HIMSS is to promote better health through information technology (IT). Our study uses the HIMSS 2014 analytics database which contains the data for 5436 U.S. hospitals. Different hospitals adopted different healthcare systems, we consider three different systems in this study, including CPOE, CCD (Computer Information Systems) and EMR (Electronic Medical Record). Descriptive statistics for CPOE implementation status are as follows: 68.4% (3718 of 5436) of the hospitals have implemented CPOE to enter medical orders. The distribution of adoption rate is summarized in Table 2:

For EMR implementation, 82.7% (4494 of 5436) of the hospitals have implemented EMR to store medical records (including digital and/or scanned data). The distribution is summarized in Table 3:

There are two moderators in our model: hospital size and IS plan. Hospital size is measured by the number of beds and the number of full-time employees of the hospital. The IS plan is measured by whether a hospital has set up a conductible plan in the following five areas (Tables 4 and 5).

If a hospital has set up a conductible plan in a particular area, we assign a score of 1, otherwise, we assign a score of 0. The total score of IS plan ranging from 0 to 5

Table 2. CPOE adoption status.

CPOE adoption rate	#of hospitals	Percentage
76–100%	2046	55%
51–75%	646	17%
26–50%	584	16%
1–25%	442	12%

Table 3. EMR adoption status.

EMR percentage	# of hospitals	Percentage
76–100%	2614	58%
51–75%	863	19%
26–50%	496	11%
1–25%	520	12%

Table 4. CCD adoption status.

For CCD implementation, 80.6% (4381 of 5436) of the hospitals have adoption CCD. The distribution is summarized in Table 4:	# of hospitals	Percentage
Using CCD	1708	39%
Not using CCD	2673	61%

Table 5. IS plan detail.

ISPlan_id1	Integration issues
ISPlan_id2	Reducing the number of software vendors
ISPlan_id3	Migrating toward a paperless environment
ISPlan_id4	Decreasing medical errors
ISPlan_id5	Computerized patient record

measures the efforts of the hospital in setting up IS plans. Performance is measured by cost and revenue. Cost is a latent variable represented by the average payroll expense (payroll expense divided by the number of full-time employees) and average operational cost (operational cost divided by the number of full-time employees). Similarly, revenue is another latent variable, and it is measured by average patient revenue (patient revenue divided by the number of full-time employees) and average operational revenue (operational revenue divided by the number of full-time employees). Table 6 summarizes all the variables and the instruments in the analysis.

Table 6. Data elements and instruments.

Element category	Variable name	Element name	Description
Performance	Pay	PayrollExpense	Payroll expense for a 12-month period, this includes all salaries and wage expenses.
	Oexp	TotalOperExpense	The total amount of money the Acute- Care Hospital spends on operations such as staffing, property expenses, etc. for the most recent fiscal year.
	Orev	NetOperRevenue	Net operating revenue includes revenues associated with the main operations of the hospital (net inpatient + net outpatient revenue). It does not include dividends, interest income or non-operating income.
	PatRvn	NetPatientRevenue	Net Patient Revenue in hospitals, is gross inpatient revenue plus gross outpatient revenue minus related deductions from revenue.
Service volume	AHA	AHAAdmissions	Number of Admissions which includes the number of adult and pediatric admissions only (excluding births). This number includes all patients admitted during a 12-month reporting period, including neonatal and swing admissions.
	NoOp	NofOutpatientVisits	Number of outpatient visits at each Acute-Care Hospital in the most recent fiscal year.
	Disch	NofTotDischarge	The total number of patients discharged from the hospital in a calendar year
	PatD	NofTotPatientDays	The number of calendar days of care provided for hospital inpatient treatment under the terms of the patient's health plan, excluding the day of discharge
Size	Size	NofBeds	Number of Licensed Beds
	NoFTE	NofFTE	Total number of FTEs
IT implementation	CPOE	CPOEMandated	Yes = healthcare system mandated that physicians utilize CPOE system
	CCD	CCD_Transaction	Yes = the hospital is using HL7 CCD (continuum of care document) transactions to share patient data with other organizations?
	EMRP	ElectronicMedRecPerc	The percent range of the hospital's current medical record that is electronic (includes digital and/or scanned data) (see tab AS-Perc Ranges)
IS plan		ISPlan_id1	Integration issues
		ISPlan_id2	Reducing the number of software vendors
		ISPlan_id3	Migrating toward a paperless environment
		ISPlan_id4	Decreasing medical errors
		ISPlan_id5	Computerized patient record
	ISPlan	ISPlan_Score	The value ranging from 1~5 to measure the IS Plan degree

Table 7. Model fit results of the complete cost model for all hospitals.

Model	NFI Delta1	RFI rho1	IFI Delta2	TLI rho2	CFI
Default model	.984	.976	.992	.987	.992
Saturated model	1.000		1.000		1.000
Independence model	.000	.000	.000	.000	.000
Model	RMSEA	LO 90	HI 90	PCLOSE	
Default model	.045	.031	.058	.738	
Independence model	.397	.388	.406	.000	

There are different types of hospitals in the data set. We focus on General Medical and General Medical & Surgical Hospitals. Next, we eliminate hospitals that have missing values. After the preprocessing, there are 522 hospitals in our sample.

5. Estimation model and results

Structural equation modeling is used to estimate the model and test the hypotheses in Figure 2. The general form of the structural equation is (Li, 1997):

$$y = \beta y + \gamma x + \varepsilon$$

where represents a p*1 vector of dependent variables measured without error; β represents a p*p matrix of coefficients relating p dependent variables to one another; represents a q*1 vector of independent variables measured without error; represents a p*q matrix of coefficients relating q independent variables to the p dependent variables; represents a p*1 vector of errors in the equation. In our case, the structural equations for the hypothesized relationships can be written as follows:

$$\begin{bmatrix} \text{Performance} \\ \text{Service volume} \\ \text{IT implementation} \end{bmatrix} = \begin{bmatrix} 0 & \beta_{12} & \beta_{13} \\ 0 & 0 & \beta_{23} \\ 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} \text{Performance} \\ \text{Service Volume} \\ \text{IT implementation} \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} \\ \gamma_{21} & \gamma_{22} \\ \gamma_{31} & \gamma_{32} \end{bmatrix} \begin{bmatrix} H\,\text{size} \\ IS\,\text{Plan} \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \end{bmatrix}$$

To examine how HIS implementation affects the hospital performance, and how such effect differs for different types of hospitals, we separate our data into two groups based on hospital size: hospitals with more than 100 beds (big hospitals) and hospitals with equal to or less than 100 beds (small hospitals). We evaluate the hospital performance from two perspectives: cost and revenue. Therefore, six models are tested to check the model fit for hypotheses: the cost model for all hospitals, the cost model for big hospitals, the cost model for small hospitals, the revenue model for all hospitals, the revenue model for big hospitals, and the revenue model for small hospitals.

Table 8. Adjust from the complete model.

Model fit statistics	Indicator cutoff	Model A (complete model)	Model B (IT_Impleme ntation = > Service_Volu me)	Model C (delete ISPlan_Score = > Cost)	Model D (ISPlan_Score = > Service_Volume)
CMIN/Df	< 3	2.033	1.988	1.948	1.909
SRMR	< .05	.0379	.0379	.0374	.0369
CFI	> .95	.992	.992	.992	.992
RMSEA	< .05	.045	.044	.043	.042
Number of insignifican t paths (ordered from the biggest *p*- value)		3 paths: IT_Implementation = >Service_Volume ISPlan_Score = >Cost ISPlan_Score = >Ser vice_Volume	2 paths: ISPlan_Score = > Cost ISPlan_Score = >Service_Vo lume	1 path: ISPlan_Score = >Service_Volu me	0 path

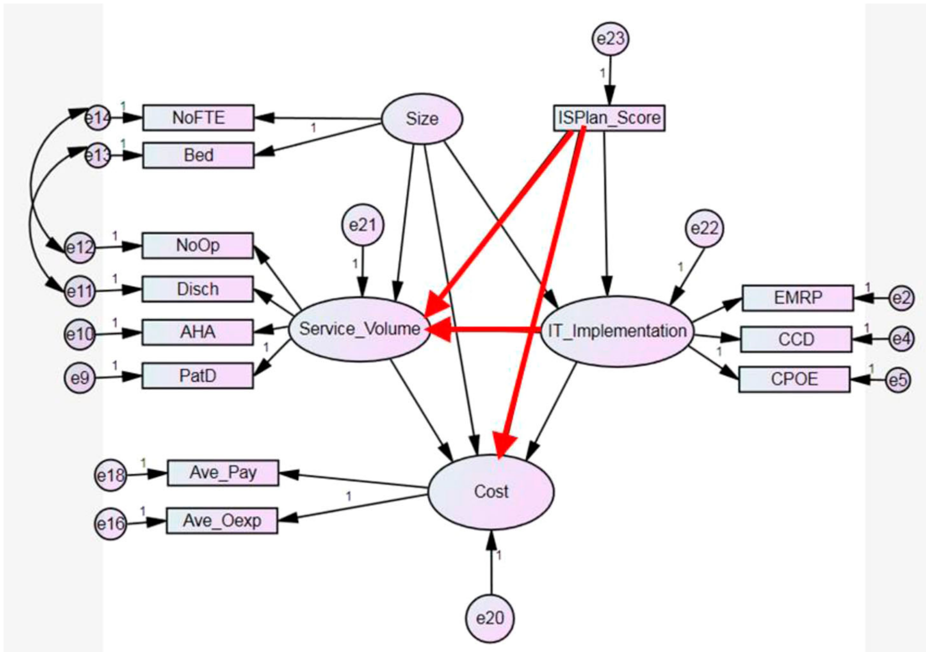

Figure 3. Insignificant paths in the complete cost model for all hospitals.

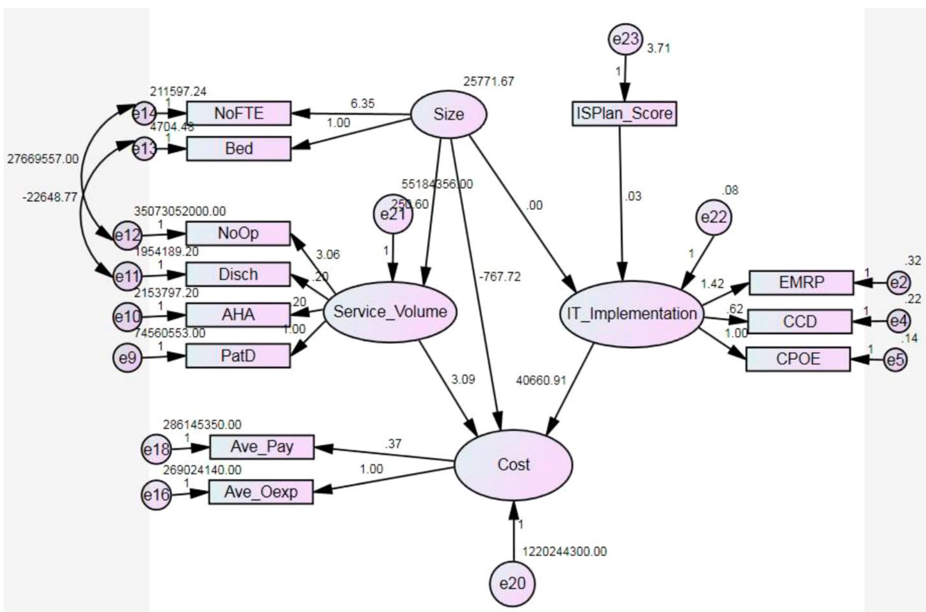

Figure 4. Result of the adjusted cost model for all hospitals.

Table 9. Model fit statistics of complete models.

Model fit statistics	Indicator cutoff	Cost all hospital	Cost small hospital	Cost big hospital	Revenue all hospital	Revenue small hospital	Revenue big hospital
CMIN/ Df	< 3	1.909	1.083	1.693	2.037	1.036	1.648
SRMR	< .08	.0369	.0638	.0438	.0375	.0622	.0412
CFI	> .95	.992	.993	.990	.992	.0998	.0992
RMSEA	< .05	.042	.025	.043	.045	.016	.041

5.1. The cost model for all hospitals

In this model, we examine the cost model which contains 522 hospitals, both large (#beds > 100) and small hospitals (#beds = <100). The result of the complete model is provided in Figure 2 (covariance links are added according to the initial output). Insignificant paths were highlighted according to the *p* value of each path load.

The results of model fit are summarized in Table 7. Hu and Bentler indicate that model fit is acceptable when CMIN/DF is below 5 and preferably below 3 (1999). The value of CMIN/DF in our model is 2.033 which is below the preferable cutoff of 3. Lei and Wu (2007) state that the standardized root mean square residual (SRMR) should be lower than 0.08, the root mean square error of approximation (RMSEA) should be lower than 0.06, and the confirmatory fit index (CFI) should be lower than 0.95. According to their model fit criteria, our proposed model is acceptable.

Next, we delete the path with the largest *P* value according to the suggested fit index (Lei & Wu, 2007). The model fit statistics for each step are summarized in Table 8 and Figure 3.

The adjusted cost model with all paths significant is shown in Figure 4. In the cost model for all hospitals, H1 is rejected, that is, IT implementation has no significant effect on service volume. H2 and H3 were rejected, the service volume and IT implementation tend to increase the hospital cost. H4 is supported. Hospital size moderates the relationships among IT implementation, service volume and cost. In particular, size is negatively related to cost and positively related to service volume and IT implementation. In other words, bigger hospitals tend to implement HIS more intensively, have higher service volume and are receiving lower average costs. H5 is also rejected since IS plan is only directly related to IT implementation but not with service volume and cost. But the results indicate that HISs are more likely to be implemented well if there are plans.

5.2. Model summary

We also test the other five models (cost small hospital, cost big hospital, revenue all hospital, revenue small hospital, and revenue big hospital) using the similar approach as illustrated previously. The model fit statistics of the complete model and adjusted model for all the six scenarios are summarized in Tables 9 and 10. The model fit of all six models are acceptable.

Table 10. Model fit statistics of adjusted models.

Model fit statistics	Indicator cutoff	Cost all hospital	Cost small hospital	Cost big hospital	Revenue all hospital	Revenue small hospital	Revenue big hospital
CMIN/Df	< 3	2.033	1.096	1.704	2.143	1.036	1.716
SRMR	< .08	.0379	.0617	.0297	.0383	.0587	.0305
CFI	> .95	.992	0993	.991	.992	.998	.0992
RMSEA	< .05	.045	.026	.043	.047	.016	.043

Table 11. Results of 5 hypotheses for 6 situations.

	H1	H2	H3	H4	H5
Cost/all	×	×	×	√	×
Cost/small	×	×	×	√	×
Cost/big	×	×	×	√	×
Revenue/all	×	√	√	√	×
Revenue/small	×	×	√	√	×
Revenue/big	×	√	√	√	×

We summarize the testing results of the five hypotheses in all six situations in Table 11. H1 is rejected in all situations, indicating that the level of IT implementation does not have a significant effect on service volume. One possible reason is HIS has not been implemented for a long enough time to significantly influence the amount of work carried out by the hospitals. H5 is also rejected in all settings, revealing that setting up HIS plans before implementation does not have a significant effect on service volume, IT implementation and financial performance. H4 is accepted in all cases indicating size is an influential moderator affecting the effectiveness of HIS. H3 is rejected in the cost models, that is, HIS implementation may increase the hospital cost. But H3 is supported in the revenue models, that is, HIS implementation also increases hospital revenue. Finally, H2 is rejected in all cost models. The increase in service volume increases the cost. However, higher service volume brings higher revenue for big hospitals (as shown in the big hospital model and all hospital model) but does not influence small hospitals.

The path load parameters indicate the significance of each path, as well as how the factors are related. We summarize the parameters of size, IS plan, service volume and IT implementation to cost (to the left) and revenue (to the right) in all three sample groups: all hospitals, small hospitals, and big hospitals. The parameter values allow us to compare the influence of the same factor across models, as shown in Table 12. IS plan shows no direct effect on both cost and revenue in all models. Even though HIS implementation increases both cost and revenue of the hospital, the increasing effect on revenue is much bigger than the increasing effect on cost, which indicates HIS implementation is beneficial to financial performance in all situations. We will discuss the influence of size separately in the following sections.

5.3. *The impact of size*

Size reduces the cost as well as the revenue for hospitals that have more than 100 beds (i.e. big hospitals). However, the magnitude of the impact is different. The decreasing impact of size on revenue is more intense than to cost. Thus, expanding in size is harmful to performance for big hospitals rather than beneficial. On the contrary, size increases both the cost and revenue for hospitals that have less than 100 beds (i.e. small hospitals). The increase in revenue is more pronounced than the increase in cost; therefore, small hospitals gain benefits in terms of financial performance when the size grows. We may conclude that size amplifies either the negative effect (for big hospitals) or the positive effect (for small hospitals).

Table 12. Influential factors to cost and revenue.

Cost (C)/revenue (R)	Size		IS plan		Service volume		IT implementation	
	C	R	C	R	C	R	C	R
All	−767.22	−1154.527	N/A	N/A	3.09	4.641	40,660.908	50,445.21
Big	−734.321	−1097.424	N/A	N/A	2.68	4.002	41,261.554	47,161.088
Small	1338.389	1680.373	N/A	N/A	N/A	N/A	46,136.23	61,611.925

We also found that size is positively related to service volume in all scenarios. This is not surprising because bigger hospitals may have more physicians and beds to serve more patients and have better facilities and equipment to deal with more complex cases. The path load from size to IT implementation is close to 0, which indicates that size has little effect on the IT implementation level. Thus, in terms of HIS quality or functionality, there is not a big difference between big and small hospitals. However, the difference in HIS effectiveness emerges within the hospitals after the hospitals apply this system.

6. Conclusion

With the rapid development of information technology, the increasing use of mobile digital devices, and efforts from the whole society, the HISs are moving towards a new era. However, there is still a lack of clear understanding of the benefits of HIS at the hospital level and the influential factors for HIS effectiveness. In this study, we empirically examine the impact of HIS implementation on hospital performance. Our research reinforces the positive effect of HIS on hospital performance. In particular, we found that HIS implementation increases both the cost and revenue of the hospitals, but the increasing effect in revenue is much bigger than the increasing effect in cost. Interestingly, hospital size plays an important role. We found that although both small and big hospitals benefit from the implementation of HIS, the effects of size are different. Size has a positive effect on hospital performance for small hospitals but has a negative effect for big hospitals. Hospitals gain benefits in financial performance when their size grows. But when the hospital size grows to a certain level, the negative effect of size on performance emerges, indicating the competitive advantage of economies of scale disappears. For small hospitals, the growth of size means more patients, more sources, more income and therefore better performance. But when a small hospital grows to a certain level, many issues arise. For big hospitals, the positive effect on financial performance caused by size (decreasing in cost) is completely offset by the negative effect (decreasing in revenue). According to information transparency theory, when the size of an organization grows, the agency costs increase. The institutional growth decreases the information transparency levels within the organization, and at the same time adds some other costs such as policy reinforcement costs, regulation costs, training costs, technical stuff costs, maintenance costs, and so on. As a result, big hospitals need to implement HIS better to maintain good financial performance. HIS can reduce communication costs and agency costs resulting from the divergence increases as the organization becomes larger (Gurbaxani & Whang, 1991). The expansion of a hospital may bring incentives to implement HIS to reduce information transparency level and transaction cost.

According to the institutional theory, the early-adopting firms would legitimize the innovative structures which improve their organizational performance. Big (also early adopter) hospitals adopt the new technologies and policies to improve efficiency, while small (also later adopter) ones may just follow to maintain legitimacy. Big hospitals receive more government support and have more incentive to implement new systems such as CPOE/CDSS/CCD than small hospitals. Our findings are consistent with Rowan's case study in California public schools that the adoption of innovative structures is slow and tentative when the institutional environment is contentious and unfocused, and larger organizations are more likely to add structured units (which help to retain new technologies, systems. once adopted) than smaller ones (Rowan, 1982). Hospitals are organizations that are highly dependent on the institutional environment and that rely on professionals extensively, thus the institutional pressures are higher than other business companies to adopt new structures (Powell & Dimaggio, 2012). Organizations adopt new structures more quickly when coercive pressures are high (such as state mandates)(Tolbert & Zucker, 1983). As a result, the adoption pattern and profitability mechanism in big and small hospitals are different. Big hospitals implement HIS mainly to reduce the transaction costs and communication costs to increase their efficiency, while smaller hospitals may be just followers to adopt HIS for compliance with the regulation.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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