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Effects of innovation leadership and supply chain innovation on supply chain efficiency: Focusing on hospital size

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ABSTRACT

This study examines the effects of innovation leadership and supply chain (SC) innovation on SC efficiency in the healthcare organization. Specifically, this study attempts to investigate the moderating effect of hospital size (more than 500 and <500 beds) on the relationships. The data used in this study were collected from relatively large hospitals with more than 100 beds. The structural equation modeling (SEM) technique with AMOS 17.0 was used to test hypotheses in the research model. The results show that innovation leadership positively affects SC innovation which in turn increases SC efficiency.

For hospitals with more than 500 beds the results confirm the effect of innovation leadership on SC innovation and a positive relationship between SC innovation and SC efficiency. On the other hand, hospitals with <500 beds hospital size is not moderated between information technology and SC efficiency, but other relationships are supported in the research model showing hospital size moderates the relationships between innovation leadership, SC innovation, and SC efficiency. The study demonstrates SC innovation plays a key role in improving operational processes for SC efficiency and contributes to the practice of healthcare management and theoretically to efficiency through innovation in supply chain management for the healthcare industry.

1. Introduction

The rapidly growing national healthcare expenditures (NHE) in the U.S. as well for developing countries are a significant issue in supply chain management (SCM) (Lee et al., 2011). Currently, information technology in healthcare systems has been receiving and deserves attention to evaluate the SC efficiency (Pai and Huang, 2011).

Healthcare providers in the United States and other nations are trying to respond to the tremendous pressure to reduce costs. Many attempts, however, are counterproductive, ultimately leading to higher costs and sometimes lower quality care (Kaplan and Haas, 2014). By 2020 supply chain will be the biggest hospital expense although today it is second (MH&L, 2015). MH&L (2015) surveyed healthcare supply chain executives and announced that over 80% agreed supply chain is extremely important for reaching profitability (89%) and revenue targets (83%), while 61% agreed cost reduction strategies in the supply chain have been extremely important in responding to customer pricing pressure. The increasing rate leads to focusing on cost reduction through hospital operational efficiency (Watcharasriroj and Tang, 2004).

To better understand the reasons why hospitals utilize SCM to reduce costs and improve efficiency and effectiveness through innovation, it is essential to analyze the various characteristics of how SCM affects performance. Innovation is a collective process of implementing ideas generated throughout resources, skills, and personnel within organizational functions and/or different organizations (Tatikonda and Rosenthal, 2000). Innovation makes it possible to achieve desired outcomes in a variety of settings (e.g., organizational performance, efficiency and/or effectiveness). Therefore, it is important to provide an environment in which healthcare leaders focus on innovation through various devices (e.g., IT applications, leadership, etc.) (Lee et al., 2011). Typically, new care services, new ways of patient care, or new technology represent innovation in healthcare systems (Länsisalmi et al., 2006). As expected, different SC require different techniques for each aspect of SCM, such as SC innovation based on hospital size. Since there is no one-size-fits-all SC, most hospital units operate multiple SCs. Thus, hospitals need to explore operations management strategies based on hospital size differences in SCM because of the importance of SC efficiency in the healthcare industry.

Previous studies related to SCM have focused mainly on reducing the delivery cost of the supply chain (EHCR, 1996; Rivard-Royer et al., 2002; Kumar et al., 2008), enhancing relationships with suppliers (Lambert et al., 1997; Kumar et al., 2008; Lee et al., 2011), and improving

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organizational performance (Lambert et al., 1997; Minkman et al., 2007; Kumar et al., 2008) in the healthcare system. However, for successful implementation of recommendable best practices there is a paucity of research that examines the influence of innovation leadership and SC innovation on SC efficiency for different sized organizations in the healthcare industry.

The purpose of this study is to examine the effect of innovation leadership and SC innovation on SC efficiency in the healthcare industry and the effect of hospital size (e.g., more than 500 and <500 beds) on the relationships in order to suggest different management strategies. More specially, the research question seeks to be answered in this present paper is as follows: (1) Does innovation leadership impact SC innovation? (2) Do process improvement and information technology of SC innovation have an impact on SC efficiency? (3) Does hospital size (e.g., <500 beds and more than 500 beds) moderate those relationships?

A research model is proposed based on previous studies and examined using the structural equation modeling approach. The rest of this paper is organized as follows: Section 2 presents a review of previous studies; Section 3 proposes a research model and hypotheses; Section 4 shows the research methodology; Section 5 reports the results of the model; Section 6 presents conclusions and discussion.

2. Literature review

Innovation is defined as the application of new ideas, processes, products, or procedures that benefit the individual, the group, or the society (West and Farr, 1990). Porter (1990) suggest that innovation is imperative to achieve competitive advantage and organizational sustainability. Also innovation is important for handling complex and often conflicting goals in the healthcare industry.

Recently, SCM has drawn significant attention in the healthcare industry because of its significant impact on hospital performance in terms of reducing waste, preventing medical errors, improving quality of care and service, and increasing operational efficiencies (Schneller and Smeltzer, 2006; Kowalski, 2009; Shih et al., 2009). Healthcare SCM presents the flow of information, funds, and goods and services (Jacobs and Chase, 2010).

SCM is referred to as “the collaborative effort of multiple channel members to design, implement, and manage seamless value-added processes to meet the real needs of the end customer” (Fawcett and Magnan, 2001). SCM is concerned with “improving both efficiency (i.e., cost reduction) and effectiveness (i.e., customer service) in a strategic context to obtain competitive advantage that ultimately brings profitability” (Mentzer et al., 2001). Also, the Institute for Supply Management (n.d.) defined SCM as “the design and management of seamless, value-added processes across organizational boundaries to meet the real needs of the end customer”. It can mean that increased efficiency and effectiveness strive to improve organizational performance.

The goal of SCM is to achieve short-term and long-term objectives by facilitating efficient and effective information flow; the short-term objective is to increase productivity and reduce delivery time while the long-term objective is to increase customer satisfaction, market share, competitive advantage, and organizational performance (Chan et al., 2008). SCM includes business activities and operations that integrate a continuous, seamless flow of material and services for healthcare delivery including SC value chain processes from suppliers that provide products, services, and information to patients (Rivard-Royer et al., 2002; Shih et al., 2009).

2.1. Innovation leadership

Leadership is widely studied in many fields as a complex topic, and it is one of the fundamental concepts in organization theory. Leadership is the most important factor affecting innovation (Cummings and O'Connell, 1978) because innovation refers to the successful implementation of creative ideas within an organization (Amabile et al., 1996; Amabile, 1998). Leadership that is focused on innovation includes transformational leadership (Elkins and Keller, 2003; Jung et al., 2003). Most organizations are engaged in innovative activities as a competitive strategy and accept innovation as an important method of organizational competitiveness and survival (Jung et al., 2003).

In order for healthcare organizations to survive in the competitive environment with ever-increasing customer expectations and continuously advancing technologies, efficient leadership is necessary for the development of organizational innovation which strengthens healthcare organizations internally as well as externally. The ability of leaders to effectively lead the organization is important to the delivery of care, customer/patient satisfaction, as well as the overall success of the organization in the healthcare industry. In addition to individuals that comprise the leadership team, each person or each medical staff team within the organization has certain leadership or management skills. Each medical staff team (e.g., surgical and internal disease affairs, dental, eye care, examination, etc.) cannot only reflect leadership traits, but can also directly impact other teams and the group's overall performance.

Carmeli et al. (2010) describe the essence of innovation leadership as “encouragement of individual initiatives, clarification of individual responsibilities, provision of clear and complete performance evaluation feedback, a strong task orientation, emphasis on quality group relationships and trust in organizational members”. Innovation leadership promotes a more adaptive organizational system (e.g., high levels of support facilitates and advances information technology) and supports employees in adapting to new, changing and creative work environments (e.g., teamwork and collaboration, motivating environment, flexibility, and resources) (Van de Ven and Chu, 1989; Hammer and Champy, 1994; Christensen, 1997; Carmeli et al., 2010; Dingler and Enkel, 2016). In addition, innovation leadership is imperative as hospitals face different challenges such as medical staff shortages, the rising need for specialized care, maintenance of accurate patient databases, a rising number of uninsured patients and increasing costs of medication. For example, Intel faced soaring healthcare costs estimated to reach $1 billion by 2012 including the steadily rising cost of care. The company tried to improve processes through process innovation using collaboration. Treatment costs of certain healthcare conditions fell by 24% to 49%. Thus, providers of healthcare services seeking quality improvements and supplier management are uniquely positioned to drive collaboration (McDonald et al., 2015).

Innovation leadership in the healthcare industry also provides inspiration for individual and organizational excellence, shares a vision, develops strategies, and increases higher quality of care and services through promoting organizational systems and supporting a creative work environment. To derive innovation in SCM, a leader must have a thorough understanding of SCM activities and have good working relationships within the organization; this includes having the right resources to support efficient operational processes throughout the healthcare organization. In this study measurement items of innovation leadership are used to evaluate leaders' behaviors in healthcare organizations based in part on innovation group leadership indicated by the Minnesota Innovation Survey (Van de Ven and Chu, 1989) and Lovelace et al. (2001).

2.2. SC innovation

As Mishra and Shah (2009) point out, innovation is a complex process that is “typically characterized by high levels of both uncertainty and equivocality”. This suggestion of uncertainty in the environment involves technological change and customer demand. In the healthcare industry, for example, patient health information is stored online and supports patient health-related business with patient approval. Patients

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may log on to their own secure portal, access and share their medical records, check lab results, renew prescriptions, deal with insurers, and communicate with doctors and nurses. Thus, organizational structures account for implementation of innovative ideas in the organization (Block, 2013).

Chapman et al. (2003) suggest service industries need to focus on SC innovation, since the effective delivery of services and benefits of innovation in SCM are high quality, lower costs, timely delivery, and effective operations. Herzlinger (2006) suggests three types of innovation in healthcare systems: customer-focused, technology-based, and integrator. The customer-focused innovation focuses on reducing patient waiting time as well as expenses and medical costs. The customer-focused innovation increases productivity of medical staffs by reducing waiting time for patients. The technology-based innovation is for improving the delivery system that depends on SC so that improved processes can provide high quality care, new types of treatment, prevention of patient diseases, reduced delivery time of products and services, and improved quality of delivered products and information technology (IT) application. Technology-based innovation provides new treatment and better quality of care services which make it easier and cheaper for consumers to obtain the care they need.

Increasingly, SCM has recognized the importance of a process-based approach to managing the business concentrating on what processes are analyzed, what sub-processes and activities are contained within each process, and how the processes should interact rather than isolating activities in traditional functional silos (Croxton et al., 2001). An efficient operational process of SC would provide better management methods through the best practices or approaches. Also, operational systems in healthcare need to improve through resulting healthcare quality and safety programs for patients (Block, 2013).

Technology has traditionally been viewed as the key to productivity improvement in manufacturing. However, technology has assumed a greater significance in service industries (Bitner et al., 2000; Cui et al., 2016). Technology in service industries help to facilitate service efficiency and effectiveness (Thompson et al., 2007; Ford and Hughes, 2007). The critical factor of SCM is the efficient and effective information sharing inside and outside of the organization. Vendors of healthcare supplies and equipment are using IT to optimize operational processes for hospital organizations' goals and relationships among supply chain members (Schniederjans and Kim, 2003; Shih et al., 2009). Further, the innovative approach has been helped by the implementation of information technologies as integrated systems.

According to Lee et al. (2011), among 243 hospitals surveyed 100.0% used EDI, 66.3% used hospital management information system (HMIS), only 2.9% used ERP systems, and 1.2% used RFID systems for SCM in Korea. The Internet has provided opportunities for organizations to make significant improvements in managing and optimizing SC through efficient and effective information flow to suppliers as well as within organizations (Boyson et al., 2003).

Therefore, hospitals and suppliers should acquire necessary information technology to achieve effective SCM based on innovation. The measurement items of SC innovation to measure employee perceptions are based on studies of Flint et al. (2008); Parnaby and Towill (2008), and Lee et al. (2011).

2.3. SC efficiency

The increasing demand for customized value stimulates the need for effective SCM to achieve minimized waste, lower costs, operational efficiency, accommodation of the higher expectations of customers and medical staff, and improved organizational performance in the healthcare industry (Shih et al., 2009). In a dynamic, competitive industry organizations and suppliers must maintain competitive advantage, favorable market position, and improved performance through efficient SC operations (Chen, 1997; Heikkilä, 2002).

Most industrial organizations pursue effective SCM. Lichocik and Sadowski (2013) suggest that SC efficiency should be approached as a function of efficiency within operational processes. The functions of efficiency addressed by Lichocik and Sadowski (2013) are reducing processes, lean, minimizing the number of links in SCM, and integrating internal processes with partners to share common objectives.

McKone-Sweet et al. (2005) suggest challenges to developing an effective SCM for the healthcare industry are "constantly evolving technology resulting in short product life cycles and high cost for physician preference items, difficulty in predicting frequency, duration and primary diagnoses for patient visits and the associated product requirements, lack of standardized nomenclature/coding for healthcare products and commodities, lack of capital to build a sophisticated IT infrastructure to support SCM efforts, and inadequate business education and SCM capabilities among hospital based buyers". Regarding these challenges and conflicts, Everard (2001) suggests a contributor is the lack of strong leadership, while Dittmann (2012) proposes leadership skills are needed for improving operational effectiveness in SCM.

Most hospitals try to achieve their goals by various approaches such as attempting to manage SC strategically to reduce costs, improve quality of care, and provide better support for front line workers to create patient value. An organization that pursues innovation of processes and technology measures outcomes of strategies and operations to ensure that systems and processes support and encourage continuous improvement in SCM (Soosay and Chapman, 2006). Although the importance of SCM is well known, it is difficult to find what, how, and where to improve SCM to maximize business results in complex and challenging environments. Thus, organizations need more, better and efficient ways to reduce waste and increase speed. Consequently, SC efficiency is a critical factor for improving organizational performance. This study modifies measurement items of SC efficiency based on Heikkilä (2002); Hsieh et al. (2007), and Lee et al. (2011).

2.4. Size of hospital

Hospital size, measured by the number of beds except emergency, surgery, and care rooms, have been identified through different approaches (Watcharasriroj and Tang, 2004; Hung et al., 2010). Large hospitals have more resources (e.g., medical staff, hospital information technology) and more advantages from economies of scale (Dewar and Dutton, 1986; Goldstein and Schweikhart, 2002; Goldstein et al., 2002). Alpar and Reeves (1990) reported large hospitals have a greater ability than smaller hospitals to hire professionals such as physicians and technicians, and have more potential to use or innovate their operational systems. Increasing in size, organizations can expand their market share and meet management challenges to improve operational efficiency (Watcharasriroj and Tang, 2004). According to Watcharasriroj and Tang (2004), large hospitals trend to operate at higher levels of operational efficiency compared with smaller ones both in management and care services. This means there is a difference in management style based on hospital size. Thus, the size of a hospital has an impact on strategies to provide higher quality of care services, improved organizational performance, and support for employees' work with encouragement, positive attitudes and behaviors.

3. Research hypotheses

This study examines the effects of innovation leadership and SC innovation on SC efficiency in the healthcare industry including the moderating effects of hospital size. The research model is shown in Fig. 1.

World congress on Healthcare Supply Chain Management (HSCM, 2008) reported the importance of innovative SCM by eliminating unnecessary costs, accelerating financial returns, implementing IT, and streamlining SCM processes. Healthcare executives addressed the importance of SCM as it relates to improving efficiencies, controlling costs and facilitating change in the healthcare industry. To drive supply chain excellence innovation leadership can create and capture the most value by using existing systems and advanced technologies.

Innovation can impact the operation of SCM for increased effectiveness as well as facilitate both radical and incremental innovation capabilities. SC innovation refers to a complex process which deals with uncertainties in the environment to provide solutions for customer needs and find better organizational processes using new technologies (Porter, 1990; Herzlinger, 2006; Lin, 2014). Innovative applications of IT lead to value creation for customers, increased efficiency and accuracy of care service delivery, and quality care (André et al., 2008; Shih et al., 2009). SC innovation helps organizations achieve SC efficiency and quality management practices which improve organizational performance. Healthcare's lack of information infrastructure hinders innovation (Birk, 2008). Healthcare product manufacturers, distributors, and hospitals independently operate to provide or receive products and services for their businesses. As a result, each organization should have proper information infrastructure to send those demand signals with the exception of automated point-of-use, vendor managed inventory systems which efficiently transmit demand signals throughout the SC (Birk, 2008). To solve these problems leaders must accelerate the pace of innovation in their processes through IT.

SC innovation allows for reduction in costs and lead time, creation of new operation strategies, provision of consistent quality, and development of flexibility for dealing with rapid changes in the business environment (Stundza, 2009). Although the healthcare environment changes rapidly, hospitals have been slower to modify and change their business models (Reiner, 2005). However, healthcare organizations have potential opportunities for improvements in SCM through process improvement and information technology (Reiner, 2005). For example, the Nebraska Medical Center has achieved significant supply chain cost savings through an automated medical/surgical inventory management system.

The goal of SC innovation is seamless interaction between supply and demand. Such innovation will utilize the tools of communication in such a way that the gap between supply and demand is bridged efficiently while quality, flexibility, and cost reductions are attained. To increase the efficiency of processes and improve the flow of information between the organization and suppliers' innovative leadership provides the advanced IT in SCM. Thus, innovation leadership may have a positive relationship with SC innovation such that the following hypotheses are proposed:

H1. Innovation leadership will positively affect process improvement as part of SC innovation.

H2. Innovation leadership will positively affect information technology applications as part of SC innovation.

The competitive global environment is forcing organizations to become lean and effective. SC innovations go through a selection process by which the fittest or best surviving ones are selected from a set of possibilities using advanced IT. Innovative applications of IT lead to value creation for customers, increased efficiency and accuracy of care service delivery, and quality care (André et al., 2008; Shih et al., 2009). Integrated process redesign for a systemic SC can help foster efficient and effective flows of material and information (Cigolini et al., 2004). Zeng (2003) advocates the effectiveness of the firm's global sourcing process is a critical issue for efficient management of SC.

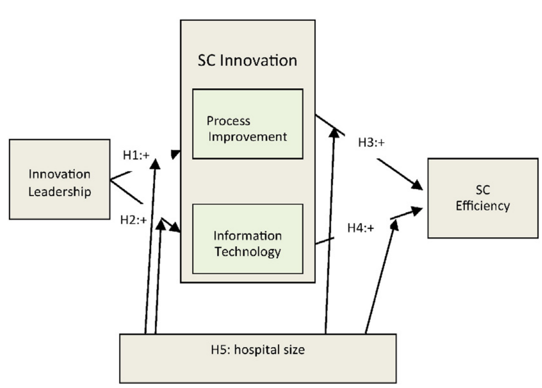

Fig. 1. The proposed model

SC efficiency is important for increasing speed and communication, removing unnecessary steps, and reducing waste and costs through process improvement and IT applications as part of SC innovation (Chen, 1997; Lee et al., 1997; Heikkilä, 2002; Heim and Peng, 2010; Lin, 2014). SC efficiency plays a vital role in improving speed and performance, eliminating waste, and developing efficient information networks all of which are supported by SC innovation. SC innovation brings about SC efficiency including reduced lead times, new operation strategies, and consistent quality (Stundza, 2009). Thus, SC innovation may have a positive relationship with SC efficiency. The following hypotheses are proposed:

H3. Process improvement as part of SC innovation will positively affect SC efficiency.

H4. Information technology application as part of SC innovation will positively affect SC efficiency.

Healthcare administrators frequently ask whether the size of their facilities has an impact on results (e.g., number of patients, patient satisfaction, performance, costs, etc.). Small sized hospitals may have low information technology applications while large hospitals are more commonly strong in advanced information technology (Watcharasriroj and Tang, 2004). This implies that the impact of hospital size seems to have a moderating effect on care service delivery processes in hospitals.

The examination of hospital size and classification by tier as potential moderators may shed additional insight about the relationships with suppliers' activities. Previous studies on SCM in the healthcare industry have rarely examined the moderating effect of hospital size (e.g., the number of beds). Sometimes patients tend to assume expertise, capacity, quality, and value of hospitals based on the number of beds and classification by tier. Since patients assume that hospital capacity affects improved treatment implications such as operating theatres, diagnostic equipment, and advanced technology, hospitals should examine how these elements operate within the facilities. Thus, characteristics of hospitals such as size may demonstrate differences in each group, and therefore, the following hypothesis is proposed:

H5. Hospital size will moderate the relationships among leadership innovation, SC innovation, and SC efficiency.

4. Research methodology

4.1. Data collection

Korean hospitals offer high-tech medical services by combining advanced IT and biotech and continue to make significant advances in the medical field. The selected hospitals for this study have more than 100 beds with the exception of emergency rooms, surgical operation rooms, doctor's offices and examination rooms. They also have logistics departments or teams.

According to the National Health Insurance (NHI) in Korea, medical service facilities are categorized based on the number of beds and degree of specialization: first tier (0–30 beds), second tier (31–700 beds), and third tier (more than 700 beds).

A survey questionnaire was developed to test the proposed model using the double translation protocol (Harkness, 2011). The questionnaire was developed in English first and then translated into Korean by the researcher who is an operations management faculty member

Table 4-1
Measurement items for the study.

Component		Measurement items	References
Innovation leadership		The top management team emphasizes team work (LE1) The top management team provides clear feedback to the employees (LE2) The top management team encourages initiatives (LE3) The top management team supports new information technology (LE4)	Van de Ven and Chu (1989), Lovelace et al. (2001).
SC innovation	Process improvement	My hospital pursues continuous innovation in core processes (PI1) My hospital focuses on innovation to reduce costs (PI2) My hospital pursues effectiveness of processes (PI3)	Flint et al. (2008); Parnaby and Towill (2008), Lee et al. (2011).
	Information technology	The IT system in my hospital is convenient to access information (IT1) The IT system in my hospital has well-informed guide material for using the system (IT2) The IT system in my hospital provides tasks that directly relate to the system (IT3)	
SC Efficiency	Waste elimination	My hospital emphasizes efforts to reduce transportation costs (WE1) My hospital involves waste reduction in processes (WE2) My hospital standardizes operation processes (WE3)	Heikkilä (2002), Hsieh et al. (2007), Lee et al. (2011).
	Speed	My hospital provides on time delivery, service speed (SP1) My hospital provides for delivery of emergency orders (SP2) My hospital provides overall average delivery lead times for formal orders (SP3)	

in South Korea. The Korean version was translated back into English by two American operations management experts who are bilingual. The two English version questionnaires based on the double translation protocol had no significant differences.

An initial questionnaire was tested in a pilot survey involving thirty-five participating hospitals in South Korea. Hospitals in this survey participated on a voluntary basis. In the pilot study the number of measurement items of each variable was reduced because some measurement items suggested by managers were difficult to measure precisely through the questionnaire. The final questionnaire is shown Table 4-1 and provides revised measurement items for innovation leadership, SC innovation, and SC efficiency based on suggestions of the participating managers in the hospitals.

Hospitals with more than 100 beds were randomly selected because small sized hospitals often do not share the complexity issues of large hospitals and may not have developed advanced technology (Goldstein and Schweikhart, 2002). Tan (2002) stated that directors and/or managers are more objective and knowledgeable with their organizations' operations. To reduce bias, we limited distribution of questionnaires to a single respondent in data collection. We factored in respondents' expertise to minimize respondent variance in each hospital. Especially in small sized hospitals the staff involved in the SC processes are generally not trained to manage SC. Questionnaires were sent to the director, vice president, or manager of the logistics departments of 600 hospitals. Subsequently, 272 hospitals returned useable questionnaires (a response rate of 45.3%).

The characteristics of hospitals and demographic information of respondents are summarized in Table 4-2. The categorized hospital types included second (88.60%) and third (11.40%) tiers. The range of the number of beds was from more than 100 to more than 1,000. The three types of respondents in the logistics departments were: managers (43.75%), directors (42.28%) and vice presidents (13.97%).

4.2. Variables of the model

The questionnaire utilized 5-point Likert scales to measure the constructs. Some measures were modified to adapt to this research. This study was conducted with SPSS 21.0 and the AMOS 21.0 programs. Structural equation modeling (SEM) was chosen because it provides all of the tools necessary to test the hypotheses.

Reliability is estimated using Cronbach's alpha values (Table 4-3). All of the coefficients for the constructs exceeded the threshold value of .70 for exploratory constructs (Nunnally, 1978). In the reliability test Cronbach's alpha for innovation leadership was the highest (0.895), and SC innovation was the lowest (0.731). All of the Cronbach's alpha values were significant at $p < 0.05$.

Validity refers to the accuracy of a measure. The principal component analysis (PCA) is used to identify the most meaningful basis and to express similarities and differences of the data. Also, the confirmatory factor analysis (CFA) is a way of testing how well measured variables represent the constructs. Statistics of the PCA and CFA are shown in Table 4-3.

As Fornell and Larcker (1981) recommend, the average variance extracted by each construct should be >0.5. All measurement items met the threshold. The loading values for all of the factors are shown in Table 4-3. The loading values of each factor ranged from 0.746 to

Table 4-2
Hospital and respondents' characteristics.

Hospitals' characteristics		Frequency	Percent (%)
Hospital type	Teaching	16	5.88
	Foundation	198	72.79
	Public	11	4.04
	Private	47	17.28
Categorized hospital type	Third tier	31	11.40
	Second tier	241	88.60
Number of beds	More than 1000	9	3.31
	More than 500	137	50.37
	More than 200 to 500	89	32.72
	100 to 200	37	13.60
Respondents' characteristics		**Frequency**	**Percent (%)**
Department	Related logistics	272	100.0
Position	Manager	119	43.75
	Director	115	42.28
	Vice president	38	13.97
Total respondents = 272			

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Table 4-3
Results of PCA and CFA.

Constructs		Variables	PCA			CFA			Cronbach's Alphas
			Eigen value	Percent of variance explained	Factor loadings	Standardized loading	*t*-value	*p*-value	
Innovation leadership		LE1	3.05	76.15	0.888	0.857	13.512	0.000	0.895
		LE2			0.875	0.823	13.005	.000	
		LE3			0.918	0.908	14.150	.000	
		LE4			0.806	0.718	–		
SC innovation	Process improvement (PI)	PI1	2.61	43.50	0.901	0.861	11.752	0.000	0.731
		PI2			0.871	0.807	11.681	0.000	
		PI3			0.812	0.717	–	–	
	Information technology (IT)	IT1	1.654	27.57	0.785	0.689	8.198	0.000	
		IT2			0.813	0.674	8.165	0.000	
		IT3			0.828	0.746	–	–	
SC efficiency	Waste elimination (WE)	WE1	2.15	35.79	0.794	0.674	7.748	0.000	0.790
		WE2			0.761	0.606	7.313	0.000	
		WE3			0.851	0.790	–	–	
	Speed (SP)	SP1	1.68	28.03	0.775	0.649	6.774	0.000	
		SP2			0.834	0.748	6.504	0.000	
		SP3			0.746	0.583	–	–	

0.918. Eigen values and percent of variance explained for each construct are shown in Table 4-3.

The standardized factor loadings and t-values for measurement variables and results of CFAs to test measurement models for each construct separately using the AMOS program are presented in Table 4-3. The values of standardized regression weights for innovation leadership, SC innovation, and SC efficiency were all >0.5, and all variables proposed by the study were statistically significant at the 0.05 level.

In this model SC efficiency involves inter-correlated latent variables that are measured by measurement models using the second-order factor method. Statistics of CFAs for first- and second-order factors are shown in Table 4-4. The results of goodness of fit tests for each measurement model to compare with first- and second-order CFAs are summarized in Table 4-4 which shows the values of chi-square (χ^2), degrees of freedom, GFI, AGFI, CFI, RMSEA, RMR, and *p*-value of each model. Compared to the recommended values for the goodness of fit tests, in each model the values of GFI, AGFI, CFI, RMR, χ^2, and the *p*-value were satisfactory while the value of RMSEA of innovation leadership (0.087) and SC innovation (0.092) was not.

The square roots of average variance extracted (AVE) of latent variables are shown in Table 4-5 while the off-diagonal elements are the correlation between latent variables. For adequate discriminant validity the square root of the AVE of any latent variable should be greater than the correlation between a particular latent variable and other latent variables (Barclay et al., 1995). Since the values of composite reliability (CR) of innovation leadership, SC innovation, and SC efficiency were all >0.7, convergent validity met the threshold. Statistics shown in Table 4-5, therefore, satisfy this requirement lending evidence to discriminant validity. The results of the correlations between each variable are shown in Table 4-5.

5. Structural equation modeling and hypothesis testing

AMOS analytical results for the study model and estimates for the model fit measures were analyzed. As a result of the goodness of fit test, compared to the recommended values, in this model the value of GFI (0.921), CFI (0.946), RMSEA (0.060), RMR (0.041) were good for fit and chi-square (192.492) and *p*-value (0.000) were significant. However, the value of AFGI (0.891) did not meet the criteria based on the recommended values.

The results of significance tests for paths of the model are shown in Table 5-1. For H1 test, the standardized path coefficient between innovation leadership and process improvement is 0.536 and significant at the 0.001 level. Thus, H1 is supported. To drive process improvement as part of SC innovation in SCM, leaders should develop effective processes and provide support with the right resources to improve high quality of care (Herzlinger, 2006; Schneller and Smeltzer, 2006; Shih et al., 2009). When SC innovation is focused on improving operational processes, innovation leadership leads to innovation, providing better value to customers through reduced costs and improved quality of products and services (Flint et al., 2008).

For the H2 test the standardized path coefficient between innovation leadership and information technology applications is 0.367 and significant at the 0.001 level. Therefore, H2 is supported. Leaders should know how and where to direct their supply chain investments to maximize business results, manage complexities and challenges, and apply better IT through supply chain innovation (Schneller and Smeltzer, 2006; Shih et al., 2009).

H3 tests the effect of process improvement as part of SC innovation on SC efficiency. A standardized path coefficient between process improvement and SC efficiency was 0.288 and significant at the 0.05 level. Thus, H3 is supported. For the H4 test the standardized path coefficient between information technology applications as part of SC innovation and SC efficiency was 0.351 and significant at the 0.01 level. Therefore, H4 was also supported. SC innovation affects SC efficiency focused on providing efficient operational processes. SC innovation for SC efficiency helps improve operations and management, increases speed, and reduces waste. The flow of dependable information through a positive relationship between customer and supplier impacts SC efficiency (Heikkilä, 2002). Concerning the effect of SC efficiency on

Table 4-4
Results of fit indices for CFA.

Model		χ^2	d.f	p-value	GFI	AGFI	CFI	RMSEA	RMR
SC Efficiency	First order CFAs	19.672	8	0.012	0.977	0.939	0.964	0.073	0.033
	Second order CFAs	19.672	8	0.012	0.977	0.939	0.964	0.073	0.033
Innovation Leadership		6.070	2	0.048	0.898	0.944	0.994	0.087	0.013
SC innovation	Process improvement Information technology	26.350	8	0.001	0.969	0.920	0.966	0.092	0.028

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Table 4-5
Correlation matrix and average variance extracted (AVE).

Factor	Innovation leadership	Process improvement	Information technology	SC efficiency
Innovation leadership	1			
Process improvement	0.480**	1		
Information technology	0.257**	0.221**	1	
SC efficiency	0.264**	0.363**	0.389**	1
CR	0.909	0.890	0.792	0.947
AVE	0.715	0.730	0.562	0.899
Sqrt (AVE)	0.845	0.854	0.749	0.948

** $p < 0.01$,

SCM, this study showed similar results as previous studies on the relationship between SC innovation and SC efficiency (Chen, 1997).

5.1. Moderating effects of number of bed capacity between groups

The test for moderating effects (H5) was conducted using two groups: more than 500 and <500 beds. The sample hospitals were also divided into two groups: more than 500 and <500 beds, second and third tiers, respectively. Structural equation modeling (SEM) with AMOS 17.0 was conducted to compare between groups to discover whether bed size and classification may moderate the relationships between the constructs under study.

To examine the moderating effect of the number of beds capacity the study employed covariance matrices to perform a measurement equivalence test via a confirmatory factor analysis (CFA) in AMOS Version 21.0. This allowed us to examine various combinations of constrained and unconstrained models to determine "the source of any differences in the way the constructs are composed and interpreted in the different cultures" (Myers et al., 2000).

The results of the CFA model comparing the two groups are shown in Table 5-2. First, the test of configural invariance (model 1) produced a χ^2 of 346.650 (df = 196), a CFI of 0.942, and an RMSEA of 0.044. The second model (model 2) was estimated to determine whether the measurement model is equivalent for the two groups. To evaluate this model factor loadings (λ) were constrained across the two groups. The χ^2 difference between models 1 and 2 was non-significant ($\Delta\chi^2 = 2.733$). This suggests that the measurement scale is assumed to be equivalent across the two groups (Myers et al., 2000). In addition, model 3, both for the factor correlations (Φ) and factor loadings (λ), is not significantly different from model 2 ($\Delta\chi^2 = 1.438$, df = 213; CFI = 0.944; RMSEA = 0.044). This finding implies that the factor correlations and the factor loadings are constrained such that they are equal (Myers et al., 2000). The fourth model (model 4) estimated the error variances (θ) to be equal across the two groups. As shown in Table 5-2, model 4 is significantly different from model 1 ($\Delta\chi^2 =$ 27.234, df = 38; CFI = 0.947; RMSEA = 0.039. On the basis of the CFA results the measurement items between the two groups assumed the steps outlined in Table 5-2, to effectively determine the path coefficients between the two groups. Given the results of the CFA presented in Table 5-2, we assumed that the measurement items for each construct suggest high convergent and construct validity.

Table 5-3 shows the results of moderating effects in the proposed model for the more than 500 beds group. All path loadings were significant at $p < 0.05$. It can be interpreted as meaning that hospitals with more than 500 beds can improve SC efficiency through innovation leadership and SC innovation in SCM. However, as shown in Table 5-3, for the <500 beds group, the results of moderating effects were significant at $p < 0.05$ for three paths: innovation leadership and process improvement (b = 0.54, $p < 0.001$), innovation leadership and information technology (b = 0.37, $p < 0.001$), process improvement and SC efficiency (b = 0.29, $p < 0.01$), but not for information technology and SC efficiency (b = 0.07, $p = 0.413$). This means that hospitals with <500 beds applied different ways to improve SC efficiency though innovation leadership and SC innovation in SCM. According to hospital type or number of beds, a leader may invest IT applications to improve SC efficiency.

As shown in Table 5-3, larger hospitals have more flexibility in dedicating resources and certain operations for successful SCM activities. The results of moderating effects of this study are similar to that of previous studies (Carr and Pearson, 1997; Wagner, 2003; Zsidisin and Ellram, 2003; Koufteros et al., 2007). In addition, this study shows that larger hospitals invest more in new, advanced IT resources for SCM excellence than smaller hospitals.

6. Conclusions and discussion

The results of this empirical study offer new insights about how healthcare providers can improve their SCM for organizational competitiveness. In hospitals with more than 500 beds the results confirm the effect of innovation leadership on process improvement (H1) and IT applications (H2) as part of SC innovation. The study found a positive relationship between process improvement (H3) and IT applications (H4) as part of SC innovation with SC efficiency. On the other hand, in hospitals with <500 beds three hypotheses were supported: H1, H2, and H3.

The above results suggest potential areas to improve hospital operations. As the results indicated, SC innovation affects SC efficiency in both groups in the study. The study showed that SC innovation plays a key role in improving operational processes for SC efficiency which in turn affects organizational performance. Therefore, successful SCM may require obtaining information from the end-user and linking resources throughout processes using the IT system for speedy exchange of information to achieve SC efficiency.

Hospitals, being required to deliver products to customers at high speed, are also required to develop efficient forecasting processes to manage the uncertainty of the environment (e.g., infection or virus). In addition, speed is key for successful SC efficiency because the speed of activities can be accomplished to meet customer needs. Also, lower operating costs and reduced waste are all benefits that grow out of SC efficiency. For example, Wal-Mart, Target, TESCO, the Food and Drug Administration and other organizations use RFID. As a result, IT has become an even more interesting topic in SCM. This has motivated others to take advantage of SC efficiency possibilities through new IT applications (Li and O'Brien, 1999; Schneller and Smeltzer, 2006).

Table 5-1
Results of significance test for paths of the model.

Path	Path coefficient	S.E.	t-value	*p*-value	Hypothesis
Innovation leadership➔process improvement	0.536	0.075	7.566	0.000***	H1
Innovation leadership➔information technology	0.367	0.079	4.791	0.000***	H2
Process improvement➔SC efficiency	0.288	0.065	3.034	0.028*	H3
Information technology➔SC efficiency	0.351	0.071	4.819	0.002**	H4

* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

Table 5-2
Results of CFA model comparison.

Model	χ2	df	*p*-value	CFI	RMSEA	$\Delta\chi^2$/df	Δ^2 Sig. Diff.
Unconstrained (model 1)	346.650	196	0.000	0.942	0.044		
λ Constrained (model 2)	349.383	207	0.000	0.942	0.043	2.733/11	No
Φ, λ Constrained (model 3)	360.821	213	0.000	0.944	0.042	1.438/6	No
Φ, λ, θ Constrained (model 4)	373.884	234	0.000	0.947	0.039	27.234/38	Yes

IT usage is important for improving operations because of ongoing processes that require improving the effectiveness and efficiency of operations (Heim and Peng, 2010). At face value, adoption of IT applications increases costs with no concomitant increases in benefits. In order to achieve a desired outcome of SC efficiency that will enhance revenues and reduce costs, process improvement and IT applications as part of SC innovation must be implemented in SCM. Also, for SC efficiency in SCM the healthcare industry has applied the just-in-time (JIT) method to achieve on-time deliveries, minimize unnecessary inventory costs, and improve efficiency (Kim and Rifai, 1992; Kim and Schniederjans, 1993).

However, other results also suggest that small sized hospitals (<500 beds) may consider altering their IT applications to better fit their strategic needs. This may mean that investment in IT is not as high of a priority as it would be in a larger organization. It may also mean the determination of IT may be a function of the skills of their personnel. In small sized hospitals some employees will be able to perform specialized tasks requiring multi-tasking and duty overlap due to more limited budgets. Thus, investment in IT does not receive the same priority as it might in a larger hospital, and greater emphasis may rightly be placed on investing in staff skill development.

Although the results of moderating effects for information technology and SC efficiency was not significant at $p < 0.05$ in <500 bed hospitals, there are many challenges related to SC innovation through IT applications necessary to support supply chain members (e.g., hospital care units, patients, and suppliers) with accuracy and real-time information which in turn facilitate efficient processes. These challenges, according to the literature, can be overcome by innovation leadership, that is, the ability to inspire individual and organizational excellence, develop a strategy for increasing quality of care and service through promoting effective operating systems and supporting a creative work environment. These goals may benefit the society through improved healthcare for better quality of life. As healthcare providers need to have the insightful advantage of IT applications, organizations also would benefit from understanding the importance of IT applications to improve SC efficiency which should be incorporated into SCM strategies for customer satisfaction and organizational performance.

The findings of the study have many implications for SCM in the healthcare industry. While SCM is enabled by advanced IT, SCM success is ultimately based on people. Thus, innovative leaders who provide an engaging environment for employees would be a key to SCM success. Through this process, operational efficiency in SCM will be assured through innovation leadership and SC innovation. This study also has important implications for employees working with suppliers. SC efficiency is an important strategy for both groups to reduce costs and provide on-time delivery in complex environments.

With regard to this study several limitations should be considered when interpreting the findings. First, data were collected from relatively large hospitals with more than 100 beds in South Korea. SCM is also important for hospitals with <100 beds and has been implemented in those hospitals and other settings such as outpatient clinics which also utilize supplies and maintain relationships with suppliers. Since there are many small-sized hospitals, a comparative study of small vs. large in terms of innovation in SCM might yield interesting results.

Secondly, this study did not investigate the type of IT applications the sample hospitals actually used in SCM. Instead, the study assumed that IT applications used in each hospital are basically the same. Large hospitals with more than 500 beds may use more systems in work processes than small hospitals. Also, the study divided the sample into two groups: more than 500 and <500 beds. Unfortunately, the sample size did not allow more groups for analysis. Furthermore, the collected data of the study was based upon using a single respondent in a hospital. This can make for bias in the dependent and independent variables. Thus, the generalizability of this study's results may be limited.

Future research should consider these limitations. The study has focused on the impact of SC innovation on SCM in the healthcare industry. SCM includes a set of complex processes which deal with uncertainties in the environment, and the very nature of healthcare systems requires SCM to deliver speedy and consistent high quality care. Hence, it is important to develop and understand appropriate operational processes with advanced IT for internal and external functions based on hospital characteristics. Researchers could explore how hospitals should deal with such complex situations and what type of specific advanced technologies could be used to provide rich information for better customer service. The exponential growth of the global supply chain and medical tourism is leading to cross-cultural interaction between hospitals and suppliers. Thus, understanding the existence of cultural differences on SCM activities is critical for healthcare excellence in the global market.

Table 5-3
Results of significance tests for paths between groups.

Path			More than 500 beds		Less than 500 beds	
			Path coefficient	p-value	Path coefficient	p-value
Innovation leadership	→	process improvement	.540	.000***	.536	.000***
Innovation leadership	→	information technology	.410	.001**	.367	.000***
Process improvement	→	SC efficiency	.261	.027*	.288	.002**
Information technology	→	SC efficiency	.272	.012*	.070	.413

* p < .05,** p < .01, *** p < .001

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