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A Lean Hospital Supply Chain Perspective to Improving Patient Care Quality

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ABSTRACT

We apply an integrated supply chain framework to the healthcare industry in the U.S., drawing support from lean systems theory. This integrated perspective can help U.S. hospitals identify and solve issues that lie outside their current boundaries. We offer a framework to streamline the three types of flows–physical product, information and financial–in the internal supply chain integrating units with technology, and maintain collaborative relations with suppliers in the external supply chain. Our propositions highlight how hospitals could deliver high quality care using an integrated supply chain perspective, coupled with internal lean practices. We discuss implications of our research.

KEYWORDS: Lean healthcare; technology integration, supplier relationship management, internal lean practices, patient care quality

INTRODUCTION

In spite of its high cost, the quality of care in the U.S. is not among the best in the world, as is evident from the discussions in the business press and healthcare journals (Davis et al., 2007; Docteur & Berenson, 2009; PGPF, 2016; Squires & Anderson, 2015; Starfield, 2000). U.S. healthcare is one of the most expensive in the world (third after Norway and Switzerland) as per health expenditure per capita data (WorldBank, 2015). The main issue is the relatively high cost of medical care in the U.S. (NationMaster, 2003; OECD, 2010). Moreover, this high cost does not always translate to quality care. While there have been many recent improvements (Boyer & Pronovost, 2010; Pronovost, Miller, & Wachter, 2006), recent reports of the Centers for Medicare and Medicaid Services (CMS) note that the degree of patient safety, an important measure of patient care quality, is still low (Boyer, Gardner, & Schweikhart, 2012). According to the Mayo clinic, improving the quality and efficiency of healthcare services available to patients and keeping their costs under control are the two most pressing needs of the U.S. healthcare industry (Toussaint & Berry, 2013).

Many problems faced by U.S. hospitals today arise beyond its own boundaries and lie with their medicine and equipment suppliers and other supporting organizations. For example, the cost of supplies now constitutes the second major component of high healthcare costs (at 31%, after 37% for the cost of facilities) (Schneller & Smeltzer, 2006). Further, hospitals and suppliers place too much emphasis on the price of the items obtained compared to their quality and the timeliness of their delivery. Hospitals are also held to the whims of the major buyer–the Group Purchasing Organization (GPO), which leverage the purchasing power of hospitals in obtaining discounts from vendors (Handfield, 2010). GPOs such as Amerinet, Consorta, Novation, Premier and MedAssets control about 72–80% of every healthcare dollar through their acquisition of supplies (Hu & Schwarz, 2011). Given the power and importance of suppliers, a few scholars in healthcare management (Coustasse, Tomblin, & Slack, 2013; Johnston & Rooney, 2012) and operations management (OM) (Cohen et al., 2008; Handfield,

2010) , as well as medical practitioners, claim that hospital supply chain management is crucial to improve U.S. healthcare (Schneller & Smeltzer, 2006).

Lean systems theory (Monden, 1981; Ōno, 1988; Sugimori, Kusunoki, Cho, & Uchikawa, 1977), an operations management (OM) theme, highlights continuous improvement in processes by focusing on essential value-adding activities and eliminating wasteful non-value added tasks. Supply chain integration and lean systems theory tenets have increased quality and productivity in many service industries such as technology consulting, software development, banking, and financial services.

Given its promise, a few scholars have already addressed a supply chain perspective in healthcare (see Brennan, 1998; McKone-Sweet, Hamilton, & Willis, 2005; Rivard-Royer, Landry, & Beaulieu, 2002; Stevens, 1989). However, the extant literature presents a limited perspective on the hospital supply chain. Although different specific aspects of hospital supply chains have been investigated, most research has followed a silo approach, and currently there is no available framework that depicts an integrated hospital supply chain. Research employing only modeling methodologies investigate specific characteristics of the external supply chain, such as the role of and problems related to GPOs (Hu & Schwarz, 2011; Hu, Schwarz, & Uhan, 2012), failing to address the internal supply chain. On the other hand, empirical research has investigated only supplier relationships from an internal hospital supply chain viewpoint, including hospital operating efficiency and supply chain performance (D. Q. Chen, Preston, & Xia, 2013b), institutional pressures on the supply chain (Bhakoo & Choi, 2013b) and hospital storage area rearrangement and related cost savings (Rivard-Royer et al., 2002). This limited perspective and absence of an integrated approach is problematic because there could be issues that originate from within the hospital or outside that have a bearing on patient care quality (PCQ). We suggest that integrating the two perspectives present a holistic supply chain approach that can help us adequately factor in all issues related to a hospital from a macro perspective which ultimately affect PCQ delivered to patients.

The lack of a clear hospital supply chain framework in healthcare literature compounds the dilemma that hospital administrators and medical experts face while deciding how to resolve several interconnected issues to provide better quality of patient care. There is no established supply chain framework in the literature that suggests methods to improve the quality of care received by patients in hospitals. The objective of this study is therefore to advocate using an inclusive approach towards improving the quality of patient care and contribute to research positioned at the cross section of operations and healthcare literature. Specifically, we investigate the following research questions: *Which internal and external hospital supply chain factors are related to patient care quality? How are these factors related to patient care quality?*

By including variables from both the external as well as the internal supply chain of a typical U.S. hospital and using lean principles as its basic underlying philosophy, this study attempts to offer a conceptual framework to improve patient care quality thereby filling the void in the literature. Full-service U.S. hospitals could use the framework to improve the quality of care available to their patients.

The framework has several useful implications for patients and medical practitioners as well. First, patients in hospitals could greatly benefit from an integration of the various entities of the healthcare supply chain because it could bring the focus of the healthcare system on the effectiveness and efficiency of all entities and their individual processes which would ultimately improve the quality of healthcare services that they receive in the hospital. Second, the framework highlights the importance of hospital leadership and lean operations and is aligned closely with the MBNQA award criteria for healthcare (NIST, 2013). The framework also directly addresses the most strategic issue raised by The American Medical Association (AMA, 2011)– quality of care. Medical practitioners involved in all hospital supply chain entities would gain from an integrated supply chain perspective because of the importance given to continuously improve quality at hospitals, steps taken to reduce hospital inventories and further, reduce and

eliminate all wastes or non value-adding activities. The framework could thus show hospitals how to use their resources better. Better quality of patient care could be provided by hospitals if they allocate the resources to support their processes that reduce medical errors and focus on overall quality of care (Byrnes, 2004; Shih, Rivers, & Soya Hsu, 2009; Singh, Rice, & Riquier, 2006). Better quality of patient care is a win-win for all stakeholders because it could improve hospitals' financial performance, benefit all intermediaries and suppliers in the chain, as well as benefit patients through better, quicker care (Lee, Lee, & Schniederjans, 2011).

Our paper is structured as follows. We first review the extant OM and healthcare literature and offer our conceptual framework of specific variables that are drawn from both the internal as well as external supply chains of a typical U.S. hospital. Next, we offer four propositions that delineate our expectations of the relationships among the variables. Finally, we discuss the implications of our research.

LITERATURE REVIEW

Supply chain management (SCM) has been defined by the Council of Supply Chain Management Professionals (CSCMP) as the "*planning and management of all activities involved in sourcing, procurement, conversion, and logistics management. It also includes the crucial components of coordination and collaboration with channel partners which can be suppliers, intermediaries, third-party service providers, and customers*" (CSCMP, 2011). In the context of a hospital, the supply chain includes all departments that are within the control of the hospital administration and also entities in the external chain (Rivard-Royer et al., 2002).

Healthcare supply chain processes are known to have three types of flows—physical product flow, information flow and financial flow (Singh, Rice, & Riquier, 2006) and it is important that all these processes are managed effectively. Physical product flow refers to the use of products, and these often vary across hospitals depending on their specialization. For example, orthopedic hospitals tend to have greater need for specialized and custom bracing for neck, back, wrist, elbow, knee, and ankle conditions, cervical pillows, Transcutaneous Electrical Nerve Stimulation (TENS) units, and custom foot orthotics for the medical treatment of patients and their special needs. Information flows consist of electronic medicine inventory information from hospital to suppliers for automatic reordering. Information flows also occur within the internal supply chain among healthcare team members. By "healthcare team" we mean the group of doctors, nurses, social workers, physical therapists, dietitians and discharge planners who work together to care for patients in most hospitals to recognize the importance of information flow among them. All members of the team who come in close contact with the patient should have the most up-to-date and accurate information on the patient's medical condition. Several articles both in healthcare literature and the business press have routinely highlighted inappropriate information flows among these team members as a source of medical errors (see Allen, 2013; Jarousse, 2016; Vest & Gamm, 2010; Waldfogel, 2013). Financial flows refer to items such as pending supplier bills for payment and pending patient bills for collection (Kowalski, 2009; Singh et al., 2006).

Next, keeping in mind patients in a typical U.S. hospital, we focus on the aspects of its supply chain that we deem to have the greatest impact on PCQ. In the remainder of this section, we discuss how an integration of all technological systems in the internal hospital supply chain, as well as how supplier relationships could be effectively managed to achieve a comprehensive lean orientation. We then describe how a comprehensive lean orientation would help hospitals deliver higher PCQ. We advance four propositions to specify our expected relationships among the variables—*technology integration, supplier relationship management, internal lean practices and patient care quality*.

Technology Integration

We define *technology integration* as the interconnectedness of the different technological systems (both software and hardware) implemented in hospitals that enables frequent and up-to-date information exchange such as hospital patient medical information, inventory data about medicine/other supplies and personnel information in electronic form between different entities within the hospital, the healthcare team and hospital management (e.g., Leidner, Preston, & Chen, 2010; Li & Lin, 2006). The tight integration present in software systems that some hospitals use reduce operational uncertainty by providing coordination, visibility, and easy information sharing across transactions (Hendricks, Singhal, & Stratman, 2007; Leidner et al., 2010). Easy access to integrated data about the latest in-house hospital stock levels may make it easier for hospital administrators to transact business with other entities, both within and outside the hospital (Huber & McDaniel, 1986; Saeed, Malhotra, & Grover, 2005). The major studies on technology integration in healthcare supply chain are presented in Table 1.

Table 1. Major Studies on Technology Integration across Healthcare Supply Chains

Study	Purpose	Research Type	Main Findings
Young and Barrett (1997)	Cross-functional-process (CFP) framework for implementing an integrated delivery system (IDS) in healthcare	Conceptual	There are ten CFPs that could be put into three categories: planning processes (strategy formulation, program adaptation, budget formulation), organizational processes (authority and influence, client management, conflict resolution, motivation, and cultural maintenance), and measurement and reporting processes (financial and programmatic). The authors suggested that senior management considers how to improve both the functioning of each CFP and the overall fit of all of them.
Devaraj and Kohli (2000)	Effect of technology and business process reengineering (BPR) on performance	Empirical	Findings support the IT-performance relationship. The authors found a positive impact of technology on performance, though the degree of impact depends on the BPR practiced by hospitals.
Sirio et al. (2003)	Pittsburgh Regional Healthcare Initiative (PRHI)'s design for change using a shared learning model	Conceptual	By linking patient outcomes data with processes of care and sharing this information widely, PRHI supported measurable improvements in region wide clinical practice and patient safety.
Ilie, Van Slyke, Parikh and Courtney (2009)	Effect of IT accessibility on adoption of electronic medical records (EMR)	Empirical	Physical accessibility is defined as the availability of computers that can be used to access EMR and logical accessibility is defined as the ease or difficulty of logging into the system. The authors found that when deciding between the paper chart and EMR, accessibility is an important consideration in a physician's decision. They concluded that accessibility limits the acceptance of IT.

Study	Purpose	Research Type	Main Findings
Korst, Aydin, Signer and Fink (2011)	Hospital readiness for health information exchange	Empirical	A tool was developed to measure hospitals' readiness for data-sharing. They found that hospital leadership is important in collaborative efforts that aim to share data for quality implementation or safety purposes.
Queenan, Angst and Devaraj (2011)	Relationship between extent of computerized physician order entry (CPOE) use and patient satisfaction	Empirical	Contrary to extant research, the authors' positive findings suggest that the relationship between the CPOE use and patient satisfaction is stronger in non-academic hospitals. They also found evidence that a hospital's IT infrastructure substitutes for CPOE use in its effect on patient satisfaction.

An examination of the research presented in Table 1 shows that scholars offering conceptual models have focused mostly on healthcare in clinical settings. The cross-functional process framework (Young & Barrett, 1997) offers an integrated delivery system model but some of the organizational processes such as client management and cultural maintenance may not apply to U.S. hospital settings. Similarly, the Pittsburg Regional healthcare initiative (Sirio et al., 2003) offers a shared learning model but some of its care processes could be local to the state of Pennsylvania. The empirical studies on the other hand, discuss several specific issues related to technology adoption and integration in hospitals, such as effect of business process reengineering (BPR) on performance (Devaraj & Kohli, 2000), technology accessibility and hospital readiness its effect on electronic medical records (EMR) (Korst, Aydin, Signer, & Fink, 2011) and the extent of using computerized physician order entry (CPOE) and its effect of patient satisfaction (Queenan, Angst, & Devaraj, 2011). Overall, many of the articles have chosen to investigate very specific and detailed issues but have ignored the systemic problems caused by lack of integrating all technology systems in the hospital.

There are several benefits of using modern technology in an integrated manner in hospitals. Technology can be used for keeping electronic patient medical records and giving e-prescriptions and other laboratory orders for patient tests directly to pharmacies or laboratories, which would ensure that medical errors due to intervention of the patient/kin are reduced (Ilie, Van Slyke, Parikh, & Courtney, 2009). Hospital information systems could provide alerts to the doctors and nurses monitoring the patient whenever any drug related complications occur (Ilie et al., 2009). Patient information systems could provide service statistics on patient occupancy rates and diagnostic tests performed in hospitals laboratories. Further, technology can support sharing the medication and other inventory information with external entities such as suppliers. Important medicinal stocks from the hospital could be automatically ordered in electronic form so as to be accurate and timely (Beier, 1995).

Accurate and useful patient information needs to flow to the healthcare team whenever needed. Similarly, hospital management needs to have access to summarized patient, hospital support systems like labs and pharmacies, accounting and financial and all other types of information when they need it to be able to make the best decisions. Therefore, it is crucial that all different software and hardware systems implemented in various departments in the hospital are able to "talk" to each other and exchange information on frequent basis (Angst, Devaraj, Queenan, & Greenwood, 2011; Devaraj & Kohli, 2000; Korst et al., 2011; Leidner et al., 2010; Queenan et al., 2011; Shin-Yuan, Chen, & Wan-Ju, 2009; Sirio et al., 2003; Teplensky, Pauly, Kimberly, Hillman, & Schwartz, 1995; Young & Barrett, 1997). In other words, the advantages of technology are realized only if all the different information technology (IT) systems in the hospital are well integrated with each other (Albani & Lee, 2007).

Supplier Relationship Management

We define *supplier relationship management* as an approach that uses social ties and interpersonal contact between a firm and its suppliers to monitor, control and encourage desirable supplier behavior (e.g., Das et al., 2006; Noordewier et al., 1990; Rivard-Royer, Landry, & Beaulieu, 2002). Using the same technology such as applications software packages and relational capital development efforts such as cross-functional involvement and joint problem solving could help both firms and their suppliers communicate inventory demand and supply position quickly (Das, Narasimhan, & Talluri, 2006; Talluri & Sarkis, 2002).

In buyer-supplier relationship literature there are two major types of classifications. The first considers the relationship as a continuous process (e.g., transformation from awareness, exploration, expansion, and commitment to dissolution) (Dwyer, Schurr, & Oh, 1987). The second classification is based on the relationships at a point in time such as relationship governance that can range from a transaction-based relationship to a strategic alliance (Cooper & Gardner, 1993; Webster, 1992), or be in the continuum between competitive and cooperative orientation (Ellram & Hendrick, 1995). A detailed review of the extant literature yielded Table 2.

Table 2. Supplier Relationship Management Characteristics Identified in Literature

Study	Noordewier et al. (1990)	Han, Wilson and Dant (1993)	Larson (1994)	Carr and Pearson (1999)	Kim (2000)	Prahinski and Benton (2004)	Ferguson, Paulin and Bergeron (2005)
Variable studied	Supplier relational governance	Buyer-supplier relationship	Supplier product quality	Buyer- supplier relationship	Dyadic relationship continuity	Buyer-supplier relationship	Relational governance
Attributes identified	Supplier flexibility	Mutual trust	Degree to which product supplies meet specifications	Special agreements with few key suppliers	Continuity expectation	Buying firm's commitment	Disagreement resolution
	Supplier assistance	Satisfactory exchange	Degree to which product supplies perform as intended	Loyalty to key suppliers		Cooperation	Mutual benefit and trust
	Supplier information exchange		Lifespan of product supplies	Frequent face to face communication		Supplier's commitment	Negotiated agreements
	Supplier monitoring		Degree to which product supplies arrive as scheduled	Direct links with key suppliers			Timely and accurate information exchange
	Continuity expectation		Degree to which product supplies are protected by packaging				Reliance in times of adversity

Table 2 Continued

Study	Wang and Wei (2007)	Tangpong, Michalisin and Melcher(2008)	Liu, Luo and Liu (2009)	Ambrose, Marshall and Lynch (2010)	Nyaga, Whipple and Lynch (2010)	Tangpong, Hung and Ro (2010)	Lumineau and Henderson (2012)
Variable studied	Relational governance	Buyer-supplier relationship	Buyer-supplier relationship governance	Buyer-supplier relationship	Buyer-supplier relationship	Buyer-supplier relationship	Supply chain governance
Attributes identified	Trust	Relational mechanisms	Relational mechanisms (relational norms and trust)	Suppliers' ability of supplier to meet accuracy expectations	Collaboration	No opportunistic behavior	Relational governance
	Commitment	Power dependence	Transactional mechanisms (jointly stipulated contractual clauses)	Suppliers' ability to meet on-time delivery standards			Contractual governance
	Coordination			Suppliers' ability to meet productivity standards			
	Joint problem solving			Ability of firm to provide timely order status to supplier			

Based on a critical review of the research summaries in Table 2, it may be noted that only a few have chosen to study different aspects of governance of the supplier relationship from a buyer's perspective, while many have focused on the buyer-relationship in general. Further, a study investigated the continuity of supplier relationships using a dyadic lens while another chose to focus on quality of supplies. A detailed review of the characteristics of each variable studied suggests that supplier relationship management is a broad construct that comprises the following six characteristics (Chung, 2012; Lumineau & Henderson, 2012; Noordewier et al., 1990): *supplier flexibility, supplier assistance, supplier information exchange, supplier monitoring, continuity expectation,* and *quality of supplies*. Unforeseen requests for adjustments in price, stock levels and emergency deliveries are opportunities for a supplier to be *flexible* to quickly change its production/delivery schedules to meet the firm's requests (Chan, Bhagwat, & Wadhwa, 2008; Noordewier et al., 1990). The extent to which suppliers are willing to help firms by going beyond the contractually bound level of conduct is defined as *supplier assistance* (Dyer, Cho, & Chu, 1998; Janda, Murray, & Burton, 2002; Noordewier et al., 1990). *Supplier information exchange* refers to the frequency and type of information provided by suppliers to the firms (Noordewier et al., 1990; Trapero, Kourentzes, & Fildes, 2012). Key information such as suppliers' long-term forecasting and future component design information could help the firms plan their own product roll-out better. The supervisory actions that firms need to take to ensure supplier performance is referred to as *supplier monitoring* (Gavronski, Klassen, Vachon, & Nascimento, 2011; Noordewier et al., 1990). *Continuity expectation* describes long term expectations of a lasting relationship between firms and their suppliers (Noordewier et al., 1990; Villena, Revilla, & Choi, 2013). *Quality of supplies* delivered by the

supplier to the firm (Gunasekaran, Patel, & McGaughey, 2004; Han, Wilson, & Dant, 1993; Larson, 1994) is also important for a long term relationship because poor quality products/services could lead to rework for the supplier and loss of reputation and image. Next, the major studies on supplier relationship management in extant healthcare literature are presented in Table 3.

Table 3. Major Studies on Supplier Relationships in Healthcare

Study	Purpose	Research Type	Main Findings
Rivard-Royer et al. (2002)	Rearrangement of storage areas for supplies can generate savings for hospitals	Empirical	There are benefits for both the hospital and the supplier under a stockless replenishment method. In this method, the distributor packs and delivers hospital supplies according to needs of each hospital unit. The study also revealed that the packing format of supplies is important for distributor.
Langabeer (2005)	Current state of healthcare supply chain management technologies	Conceptual	The author opined that hospital supply chain orientation, from suppliers through the delivery of patient care is a relatively new concept in hospitals. He also suggested that in the future, predictive modeling, data mining and business intelligence will be used in healthcare like in other service industries.
Fredendall, Craig, Fowler and Damali (2009)	Internal service supply chain of the surgical services department of a non-academic community hospital	Empirical	Using the theory of swift and even flow (TSEF) for their analysis the authors' findings suggested the need to incorporate supply chain coordination into the theory.
Sinha and Kohnke (2009)	3A-framework founded on affordability, access, and awareness	Conceptual	The authors present a framework, which is applicable for implantable device-based care for cardiovascular diseases in developing countries. Their framework identifies integrated continuous improvement and innovation initiatives to bridge the gap between the demand and supply for high-quality, cost-effective and timely care.
Hu and Schwarz (2011)	Controversial role of GPOs in healthcare supply chain	Modeling	GPOs reduce manufacturers' incentives to innovate. They also examined the consequences of removing the contract administration fees (CAF) that GPOs charge manufacturers and concluded that it would not influence any stakeholder profits or costs.

Table 3 Continued

Study	Purpose	Research Type	Main Findings
Hu, Schwarz and Uhan (2012)	Impact of GPOs on healthcare product supply chains	Modeling	Although CAFs influence the distribution of profits between manufacturers and GPOs, they do not affect the providers' total purchasing costs.
Bhakoo and Choi (2013a)	How institutional pressures and heterogeneity affect different elements of the healthcare supply chain	Empirical	The authors examine how organizations in different tiers of a healthcare supply chain respond to institutional pressures when implementing inter-organizational systems for coordination. The study shows how different institutional pressures such as coercive, mimetic, and normative act across the tiers. It also demonstrates how a mix of endogenous and institutional pressures leads to organizational responses.
Chen, Preston and Xia (2013a)	Improving hospital operating efficiency to reduce costs	Empirical	The following factors affect hospital supply chain performance: trust, knowledge exchange, IT integration between the hospital and its suppliers, and hospital-supplier integration. Their results show that trust and IT integration affect knowledge exchange, knowledge exchange and IT integration affect the hospital-supplier integration, and hospital-supplier integration affects hospital supply chain performance.

The research summaries in Table 3 suggest that the studies employing modeling methodologies have chosen to investigate specific characteristics of the external hospital supply chain-the role of and problems related to GPOs (Hu & Schwarz, 2011; Hu et al., 2012). Empirical papers, on the other hand, have chosen to investigate different aspects of supplier relationships from an internal hospital supply chain viewpoint-factors that determine hospital operating efficiency and supply chain performance (D. Q. Chen et al., 2013b), effect of institutional pressures on the supply chain (Bhakoo & Choi, 2013b) and hospital storage area rearrangement and related cost savings (Rivard-Royer et al., 2002). The current study is different from the major existing studies discussed above because it uses a more comprehensive construct that comprises the following six aspects–supplier assistance, supplier flexibility, supplier information exchange, supplier monitoring, continuity expectation and quality of supplies. These six characteristics are conceptually inter-related with each other and depict an aspect of supplier behavior and the focal firm's response.

In healthcare, the degree that the supplier is able to adapt to meet hospitals' needs and changes in quantities of supplies ordered represents the *supplier flexibility*. Suppliers need to respond quickly to all hospital requests. Further, suppliers should be able to make changes in quantity delivered and schedule well on time as required by the hospitals. Suppliers must be able to adjust their inventories to meet unforeseen needs that hospitals may have; they should be able to provide emergency deliveries to the hospitals (D. Q. Chen, Preston, & Xia, 2013a; Goodman & Jones, 2013; Noordewier et al., 1990). *Supplier assistance* refers to the help that the supplier is willing to provide hospitals in all matters related to the quality and quantity of their delivered goods or supplies. Hospitals may want to involve their key suppliers in the redesign of existing products such as replacing existing equipment with better and more efficient ones and using more effective medication but suppliers would need to cooperate. Further, suppliers have to be willing to provide their detailed financial information to hospitals for their item-wise cost-

value analysis (Goodman & Jones, 2013; Noordewier et al., 1990). *Supplier information exchange* refers to the dyadic exchange of daily information that takes place between the supplier and the hospital is the third dimension. Hospitals need to provide suppliers with long-range forecasts of their requirements. They need to inform suppliers in advance of impending changes in products used along with the specifications and provide specific and detailed information about the quantity of supplies that they will need in the future so that the suppliers can plan their production schedules (Goodman & Jones, 2013; Langabeer, 2005; Noordewier et al., 1990). *Supplier monitoring* refers to the degree of overseeing and supervision that is required by the hospital to ensure that the supplier is responsive and is able and willing to supply the required quality and quantity of supplies. Hospitals should assess suppliers' performance through a formal vendor evaluation program and have procedures to inspect materials from suppliers. Further, hospitals should conduct quality training for supplier personnel and advise each supplier of their performance (Goodman & Jones, 2013; Noordewier et al., 1990). *Continuity expectation* refers to both parties' long term inclination to maintain ties. Hospitals should have a mutually beneficial professional relationship with their suppliers and expect suppliers to proactively resolve issues, expecting suppliers to improve their relationship with them over time. Hospitals need to have long term supplier relationships because of the advantages of trust with long term suppliers and the high costs associated with selecting new suppliers (Goodman & Jones, 2013; Noordewier et al., 1990). The *quality of supplies* refers to whether the products and services provided by the suppliers to hospitals meet the prescribed medical standards (Gunasekaran et al., 2004; Han et al., 1993; Larson, 1994; SherwoodValve, 2011). For suppliers, a way to ensure that they are able to deliver high quality supplies is by implementing quality management in their goods production/service generation units. Supplier quality management refers to a firm's quality practices such as relying on suppliers' process control as an indication of its high quality standards and ensuring that each time only high quality products are purchased (Kaynak & Hartley, 2008). Supplier quality certification may be used by suppliers to add value to hospitals. Certified suppliers could help hospitals assure everyone about the high quality of medical supplies used. Further, in order to ensure defect free quality in all of its product supplies, suppliers need to have a manual describing their quality system that must be followed by all its employees. Suppliers need to calibrate their equipment against the product and equipment standards set by the National Institute for Standards and Technology (Goodman & Jones, 2013; SherwoodValve, 2011).

Due to the nature of many healthcare service delivery process in which suppliers may contribute directly to service delivery (e.g., outsourced ambulatory services) failures in supplier services can create life-threatening risks for patients (Baltacioglu, Ada, Kaplan, Yurt, & Kaplan, 2007). Therefore, to effectively manage their supplier relationships, hospitals need to pay attention to all the above six aspects of the relationship discussed above.

Internal Lean Practices

Lean/JIT (Monden, 1981; Ōno, 1988; Sugimori et al., 1977) is a strategy that strives to improve firms' operating performance (Azadegan, Patel, Zangoueinezhad, & Linderman, 2013) by reducing the in-process inventory and associated carrying costs. In services, lean practices can be applied to improve the quality system being followed by a firm, clarify all process flows, revise process technologies to ensure that the latest techniques are being implemented correctly, level facility load, eliminate unnecessary activities, reorganize physical configuration, introduce demand-pull scheduling and develop supplier networks (Chase, Jacobs, & Aquilano, 2006). These activities help a firm streamline its operations by ensuring supplier cooperation, reduced waste in terms of safety stocks and smooth process flow.

We define *internal lean practices* as aligned hospitals operations required to achieve the outcome of performing effective medical procedures on patients in a timely manner at a

reasonable cost (e.g., Alexander, Halpern, & Lee, 1996; Butler & Leong, 2000; Cook & Rasmussen, 2005; Goldstein, Ward, Leong, & Butler, 2002; Harper, 2002; Hay, 2003; Li, Rao, Ragu-Nathan, & Ragu-Nathan, 2005; Shah & Ward, 2003). An extensive review of lean literature is presented in Table 4.

Table 4. Characteristics of Lean Operations Identified in Literature

Study	Mehra and Inman (1992)	Sakakibara et al. (1993)	Flynn et al. (1995)	Lawrence and Hottenstein (1995)	Spencer and Guide (1995)	Dean and Snell (1996)
Attributes[a]	Setup time reduction	Setup time reduction	*Kanban*	JIT deliveries from suppliers	Set-up reductions	Change in the number of suppliers in the past five years
	In-house lot sizes	Small lot sizes	Lot size reduction	Inventory reduction	Lot size reductions	Change in the size of their deliveries in the past five years
	Group technology	JIT deliveries from suppliers	Daily schedule adherence	Manufacturing strategy	Preventive maintenance	Change in the length of product runs in the past five years
	Cross-training	Supplier quality level	Setup time reduction	Employee involvement	Physical layout management	Change in the number of total parts in the past five years
	Preventative maintenance	Small-group problem solving		Employee responsibility	Plant-wide program adoption of JIT methods	Change in the amount of buffer stock in the past five years
		Training		Supplier involvement	In-house quality	
		Daily schedule adherence		Process modification		
		Preventive maintenance				
		Equipment layout				
		Product design simplicity				
		Kanban				
		Pull system support				

Table 4 Continued

Study	Forza (1996)	Jayaram and Vickery (1998)	Claycomb, Droge and Germain (1999)	Sim and Curtola (1999)	Callen, Fader and Krinsky (2000)	Fullerton and McWatters (2001)	McKone et al. (2001)
Attributes	JIT deliveries from suppliers	Reduced setup times	JIT with customers	Pull system	Inventory performance	Focused factory	JIT delivery by suppliers
	JIT link with customers	Small lot sizes		Setup time reduction	Integrated product design	Group technology	Just-in-time link with customers
		Pull system		Preventative maintenance	Integrated supplier network	Reduced setup times	Pull system support
				Repetitive nature of master schedule	Preventive maintenance programs	Productive maintenance	Repetitive nature of master schedule
					Education about JIT	Multifunction employees	Setup time reduction
					Stable cycle rates	Uniform workload	
					Market paced final assembly		
					Group technology		
					Quality improvement programs for products and processes		
					Flexibility of workers' skills		

Table 4 Continued

Study	Brox and Fader (2002)	He and Hayya (2002)	Das and Jayaram (2003)	Shah and Ward (2003)	Ketokivi and Schroeder (2004)	Nahm, Vonderembse and Koufteros (2004)
Attributes	Minimum inventory in supply chain	Setup time reduction	Setup time reduction	Reduced lot sizes	JIT deliveries from suppliers	Reengineering setups
	Production and materials control pull	Training	Kanban	Continuous flow production	Setup time reduction	Cellular manufacturing
	Employee participation/ involvement	Daily schedule adherence	Group technology	Pull system	Pull system support	Quality improvement efforts
	Reduction of wastes	Preventative maintenance	Preventative maintenance	Cellular manufacturing	Manufacturing cost performance	Preventative maintenance
			JIT supply	Reduced cycle time		Pull production
				Focused production		
				Agile manufacturing		
				Quick changeover		
				Bottlenecks removed		
				Reengineered processes		

Table 4 Continued

Study	Challis, Samson and Lawson (2005)	Li et al. (2005)	Swink, Narasimhan and Kim (2005)	Cagliano Caniato and Spina (2006)	Narasimhan, Swink and Kim (2006)	Ward and Zhou (2006)
Attributes	Preventative maintenance	Reduced set-up times	Pull system in production	TQM, six sigma quality programs	Cellular manufacturing	Lead time performance JIT has a significant and positive relationship
	Setup time reduction	Small lot sizes	Produce in small lot sizes	Pull production	Pull system	Cycle time reduction with lead time performance
	Close relationship with suppliers	Pull-production	JIT flow production methods	Cellular layout	Small lot sizes	Agile manufacturing strategies
	Production cycle time		Production flow utilizes manufacturing cells		JIT link with customers	Quick changeover techniques
	On-time delivery				JIT deliveries from suppliers	Focused factory production systems
					Daily shipments from suppliers	JIT/Continuous flow production
					Product flexibility	Cellular manufacturing
						Lot size reduction
						Pull system/Kanban
						Bottleneck removal

Table 4 Continued

Study	Avittathur and Swamidass (2007)	Matsui (2007)	Dal Pont, Furlan and Vinelli (2008)	Browning and Heath (2009)	Demeter and Matyusz (2011)	Olhager and Prajogo (2012)	Azadegan et al. (2013)
Attributes	JIT deliveries from supplier	Daily schedule adherence	Daily schedule adherence	Visual replenishment systems	JIT		Product/ process improvement efforts
		Equipment layout	Equipment layout	Non-value-adding task elimination	TQM	Processes and machines close by	Daily planned equipment maintenance
		JIT delivery by suppliers	JIT deliveries from suppliers	Balanced distribution of work	Total productive maintenance	Lower set-up times	Process variance reduction
		JIT link with customers	JIT link with customers	New technologies and tools for fabrication	HRM	Use *kanban* pull system	Low equipment set up times
		Kanban	Kanban	Standard work methods			Pull production system
		MRP adaptation to JIT	Setup time reduction	Flow shop layout			Customer feedback on quality and delivery performance
		Repetitive master schedule	Small lot sizes	Concurrent engineering			Supplier feedback on quality and delivery performance
		Setup time reduction		Design for manufacturing and assembly			Grouped equipment to produce continuous flow
		Small lot size		6S (sort, straighten, shine, standardize, safety, sustain)			Process variance reduction
		Product capability		Discontinuous improvements			
	Avittathur and Swamidass (2007)	Matsui (2007)	Dal Pont, Furlan and Vinelli (2008)	Ergonomic work stations			
	JIT deliveries from supplier	Daily schedule adherence	Daily schedule adherence	Dissemination of lean through supplier network			
		Equipment layout	Equipment layout	Work sequencing			

Notes. [a] Based on Azadegan et al. (2013) and Mackelprang and Nair (2010)

An in-depth review of 32 studies presented in Table 4 reveals that lean/JIT is being investigated in operations and strategy literature for more than two decades now. A total of 89 characteristics of lean systems have been identified, which may be broadly grouped into the following three categories–*material flow management, continuous quality improvement* and *waste management* (Azadegan et al., 2013; S. Li, Rao, Ragu-Nathan, & Ragu-Nathan, 2005; Mackelprang & Nair, 2010; Shah & Ward, 2003). *Material flow management* refers to the continuous flow of production work in process without hindrance through the production factory or service generation unit (Benton et al., 2010; Chongwatpol & Sharda, 2013; Petersen & Wohlin, 2011). *Continuous quality improvement* refers to incremental improvement in quality standards of a firm on a regular periodic basis and is one of the key pillars of lean implementation (Aravindan & Devadasan, 1995; McFadden, Jung Young, Gowen Iii, & Sharp, 2014; Moran, 1992). Wastes refer to processes that add no value to the product/service or customer. *Waste management* refers to identifying, controlling and eliminating waste (Womack & Jones, 2010). Waste can occur in areas such as transportation, inventory, motion, waiting, overproduction, over processing and defects (Waring & Bishop, 2010). Next, the major studies on lean hospital operations are identified in Table 5.

Table 5. Major Studies on Lean Healthcare Operations

Study	Purpose	Research Type	Main Findings
Pocha (2010)	The implementation challenges of lean six sigma in healthcare	Conceptual	The author highlights the important lessons that were learned from lean six sigma implementation at a tertiary care medical center. These included guidelines to follow a team approach, have the "buy in" of all the stakeholders and to have the willingness of team members to change daily practice in order to adapt new and innovative ways of delivering better quality healthcare.
Graban (2011)	Improving quality, patient safety and employee satisfaction in hospitals using lean principles	Empirical	In this book, beginning with a historical perspective of lean, the author builds a case of why hospitals need a lean outlook and how lean implementation can help hospitals achieve their goals. Among the many directly measurable advantages, reduced turnaround time for clinical laboratory results, reduced instrument decontamination time, reduced patient deaths, reduced patient waiting times, increased surgical revenue and reduced patient length of stay, are some of the common ones that some of the U.S. hospitals have experienced after becoming lean.
LaGanga (2011)	Lean service operations	Empirical	Using action research methodology this outpatient clinical field research examines appointment data. The author analyzes a lean process improvement project that was conducted to increase capacity to admit new patients. The author's findings bring several insights about effective alignment of clinical resources, how clinics develop new strategies for responding to no-shows and highlights time-related variables that have been overlooked in appointment scheduling research.
Mazur, McCreery and Rothenberg (2012)	Facilitating learning during early stage of lean implementation in hospitals	Empirical	According to the author, some healthcare organizations have successfully used lean to help solve their quality and cost related problems. Most organizations accept that the challenge to sustain the lean philosophy is in continuing to learn the behaviors that are associated with lean improvement efforts. This article examines the lean implementation process in three rural hospitals, using involved healthcare professionals as lean participants and gives recommendations for facilitating lean thinking.
Toussaint and Berry (2013)	Path to becoming lean in healthcare	Empirical	The authors suggest six principles that hospitals would need to consider in their quest to become lean: an attitude of continuous improvement, value creation, unity of purpose, respect for front-line workers, visual tracking, and flexible rules. The authors provide case studies in support of these principles. Their paper aims to provide a template for healthcare leaders to use in lean implementation.

An examination of the research summaries in Table 5 highlights some of the challenges of lean implementation in healthcare such as having all stakeholder approval and having the willingness of team members to change daily practices in order to adapt new and innovative ways (Pocha, 2010). Research has also focused on identifying steps that hospitals take to facilitate learning during their early stage of lean implementation such as using involved healthcare professionals as lean participants (Mazur, McCreery, & Rothenberg, 2012). Based on his lean consulting experience, Graban (2011) has suggested some best practices for hospitals to follow in order to improve quality, patient safety and employee satisfaction while implementing lean practices. Research has also identified some of the paths that healthcare providers may need to follow to become lean such as inculcating an attitude of continuous improvement, value creation, unity of purpose, respect for front-line workers, visual tracking and flexible rules throughout the hospital/healthcare organization (Toussaint & Berry, 2013). The studies presented in Table 5 also reveal that while lean has been related to patient care quality, only case studies and action research methods have been used and no statistical test has been demonstrated yet in the U.S. hospitals. Most healthcare studies have concentrated on two characteristics–*continuous quality improvement* and *waste management*–ignoring *patient and material flow* in hospitals.

To determine the range of lean practices to implement, hospitals should consider the concept of service packages. In the healthcare context, the hospital check-up rooms are the supporting facilities. The medical equipment like a physician's stethoscope and sphygmomanometer, a surgeon's knife and other medical technology-related items like robots are the facilitating goods. Treating the illness that the patient is suffering from by giving appropriate medicines and/or performing the required medical procedure constitute the explicit services. Implicit services comprise procedures such as checking the patient for related and even unrelated complications like allergies that the patient may already have, and/or those that may arise from the medicines/procedures, counseling and trauma therapy/services in cases of life-threatening illnesses like cancer, or in procedures like amputation of limbs. All four components of healthcare service package are taken into consideration in the subsequent discussion on how hospitals can streamline their internal operations.

Patient and material flow management imply that the hospital follows efficient patient admission and discharge procedures. It also implies that appropriate hospital facilities like ICU are available to patients when required so that their procedures are not delayed and housekeeping ensures that equipment such as drip stands are available when required (Alexander et al., 1996; Butler & Leong, 2000; Cook & Rasmussen, 2005; Devaraj, Ow, & Kohli, 2013; Goldstein et al., 2002; Harper, 2002; Hay, 2003). Hospitals could employ scheduling software that factor in the patients' medical conditions and needs along with the hospital room and equipment availability information together so that both patient and material flow within the hospital could be streamlined. *Continuous quality improvement* considers whether healthcare teams internalize the lessons learnt from past mistakes on patient safety so as not to repeat them. Hospitals could use operational data from electronic clinical information systems to plan its staffing of doctors, nurses and other employees and up-to-date advanced medical equipment and technologies while performing all medical procedures. Healthcare teams in hospitals must strive to perform the correct medical procedures the very first time that they treat a patient (Albani & Lee, 2007; Axon & Williams, 2011; Butler & Leong, 2000; Goldstein et al., 2002). Hospitals need to keep abreast of the latest technological breakthroughs in the field (Hay, 2003). Upgraded physical infrastructure of labs, operation theatres and intensive care units (ICU) and other more basic elements like hospital beds are also necessary (Butler & Leong, 2000; Goldstein et al., 2002). Hospitals need to inculcate the best equipment and medical technology and share the best practices among their employees which is consistent with one of Deming's (1993) 14 point recommendations–to encourage cooperation among all employees to improve quality and productivity. Continuous quality improvement is thus a key element of lean

implementation in hospitals. W*aste management* refers to whether hospitals use a ‘‘pull’’ production system wherein all supplies are inventoried as and when required, and whether hospitals push suppliers to achieve shorter lead-times. It incorporates whether hospitals streamline their own ordering, receiving and other paperwork from suppliers, and whether healthcare teams optimally uses all medical consumables to eliminate wastes (Hirano, 1995; Labarere, Francois, Auquier, Robert, & Fourny, 2001; Wakefield, Uden-Holman, & Wakefield, 2005; Wearmouth, 2001). Physical environment is an important attribute of lean operations. It includes the features of surroundings in which healthcare is delivered (i.e., whether the facilities and equipment used are orderly, the degree of pleasantness of hospital room atmosphere, the clarity of signs and directions to different facilities within hospitals). Effective housekeeping is an essential method of maintaining cleanliness and removing/minimizing wastes in hospital departments and helps streamline the entry and discharge procedures in a hospital (Labarere et al., 2001; Wakefield et al., 2005; Wearmouth, 2001). A clean and organized workplace is a key component of the 5-S philosophy, an overall approach to lean systems (Hirano, 1995).

Patient Care Quality

In extant literature, many studies have focused on identifying the determinants of PCQ, but all have focused on the characteristics of either the disease or ailment, or the type of medical procedure. One of the popular definitions in the extant healthcare operations literature is the classification of all healthcare practices into two—*clinical* and *experiential quality* (Chandrasekaran, Senot, & Boyer, 2012; Nair, Nicolae, & Narasimhan, 2013), which is too simplistic. *Clinical quality* reports how well physicians/nurses in both hospitals or in their private clinics conform to standardized procedures to diagnose/medically treat patients’ health problems (Cf. Nair et al, 2013; Marley, Collier, & Meyer Goldstein, 2004; Theokary & Ren, 2011; and Chandrasekaran et al., 2012). Clinical quality, in general, reflects the conformance and adherence of the physicians/nurses to standardized best practices that have been shown to result in positive patient outcomes (Cf. Nair et al, 2013; Garvin, 1987, Jha, Li, Orav & Epstein, 2005, Tucker et al., 2007, Boyer et al., 2012; Chandrasekaran et al., 2012). *Experiential quality*, on the other hand, refers to external quality capabilities that emphasize quality of the service experienced by the patient and the consequent customer satisfaction (Cf. Nair et al, 2013; Flynn et al., 1997; and Sousa, 2003).

Without delving into the detailed technical realms of each ailment and the medical procedure performed as traditionally done in most healthcare studies, we define *PCQ* in a broad and comprehensive manner to denote the excellence of the medical care received by admitted hospital patients (e.g., Chang, Ma, Chiu, Lin, & Lee, 2009; Ma, Yang, Lee, & Chang, 2009; Nelson & Niederberger, 1990; Van Ess Coeling & Cukr, 2000; Ware et al., 1983). In extant literature, a few studies, listed in Table 6, have focused on the identifying the determinants of PCQ, both in hospital and clinical settings.

Table 6. Patient Care Quality Dimensions Identified in Literature

Study	Donabedian (1968)	McFadden, Stock and Gowen (2006)	Dagger et al. (2007)	Isaac, Zaslavsky, Cleary and Landon (2010)	Boyer et al. (2012)	Chandrasekaran et al. (2012)	Nair, Nicolae and Narasimhan (2013)
Attributes	Application of modem scientific medicine	Patient safety	Interpersonal quality	Communication with nurses	Patient satisfaction data collection	Clinical quality	Clinical quality
	Emphasizes prevention		Technical quality	Communication with doctors	Quality teams of employees	Experiential quality	Experiential quality
	Requires cooperation between patients and physicians		Environmental quality	Responsiveness of hospital staff	Statistical quality (process control using control charts)		
	Considers the individual as a whole		Administrative quality	Pain management	Competitive benchmarking of best-in-class processes		
	Maintains close and continuing personal relation between physicians and patients			Communication about medicines			
	Coordinated with social welfare work			Discharge information			
	Includes all types of medical services			Cleanliness and quietness of hospital			

A review of the studies cited in Table 6 reveal that a total of 25 different characteristics related to PCQ such as cooperation between patients and physicians, cleanliness and quietness of hospital, and coordination with social welfare work have been identified. Based on an extensive search and a synthesis of the multi-dimensional nature of PCQ discussed in extant literature (Dagger, Sweeney, & Johnson, 2007; Gill & White, 2009) we suggest that PCQ has the following four dimensions: *interpersonal, technical, environmental* and *administrative quality*

Interpersonal quality reflects the relationship developed and the dyadic interplay that occurs between the healthcare team and the patient (Dagger, Sweeney, & Johnson, 2007; Gill & White, 2009). It takes into consideration issues such as whether healthcare teams treat their patients with respect, healthcare team members listen to what patients have to say, members give personalized attention to patients and whether team members are willing to answer questions that the patient or their kin may have (Dagger et al., 2007). *Technical quality* reflects the expertise, professionalism, and competency of the healthcare team in delivering the cure (Dagger et al., 2007; Gill & White, 2009). It is concerned with whether patients are administered the correct medical care that is required to cure their ailment, tests (e.g., X-rays and lab tests) are ordered on patients only when required, healthcare team members are qualified, and whether they carry out their tasks competently (Dagger et al., 2007). *Environmental quality* comprises hospital atmosphere such as cleanliness and order and tangibles like hospital bed and required equipment for patient health needs (Dagger et al., 2007; Gill & White, 2009). It takes into account whether the design of the hospital is patient friendly, the lighting at the hospital is appropriate, the temperature at the hospital is pleasant and whether the furniture at the hospital is comfortable (Dagger et al., 2007). *Administrative quality* facilitates the production of the core medical cure while adding value to the patient (Dagger et al., 2007; Gill & White, 2009). Considerations such as whether the internal hospital services (e.g., pathology) work well, waiting time at the hospital is minimum, the hospital provides patients with a range of patient support services and whether the hospital records and documentation (e.g., billing) are error free (Dagger et al., 2007) are in the domain of this dimension of quality.

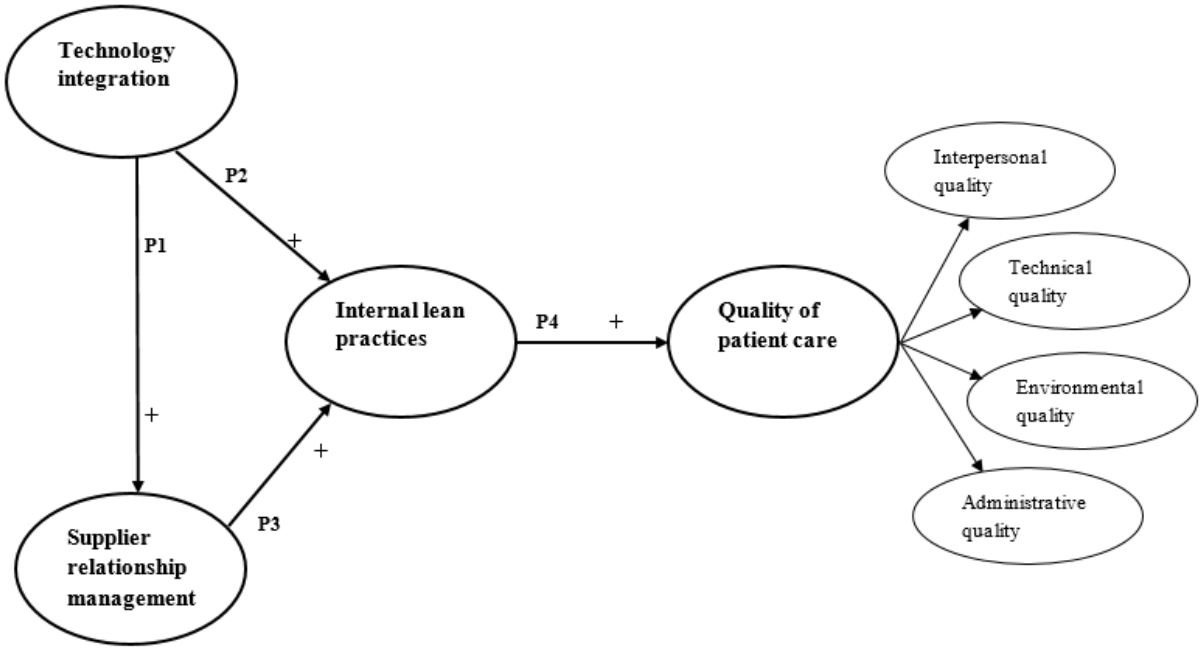
Hospitals could provide high quality of admitted patient care if they give importance to all the variables and the interrelationships described in the research model which would reduce medical errors and help them operate at the highest level of efficiency (Byrnes, 2004; Shih et al., 2009; Singh et al., 2006). Hospitals delivering high quality of admitted patient care is very crucial for all stakeholders because it could improve hospitals' financials, benefit all entities in the supply chain, and help the patients directly through better and more responsive medical care that cures them of their ailments quicker and at lower cost (Lee et al., 2011).

In the next few sections, we first offer a summary of all research constructs in Table 7. Then, the framework of variables proposed in this research, is depicted in Figure 1. Finally, we discuss the specific relationships proposed among the constructs.

Table 7. Definitions of the Constructs

Constructs	Definition
Technology integration	The interconnectedness of the different technological systems (both software and hardware) implemented in hospitals that enables frequent and up-to-date information exchange such as hospital patient medical information, inventory data about medicine/other supplies and personnel information in electronic form between different entities within the hospital, the healthcare team and hospital management (e.g., Leidner, Preston, & Chen, 2010; Li & Lin, 2006).
Supplier relationship management	A relationship building approach adopted by firms that uses their social ties and interpersonal contact with their suppliers to monitor, control and encourage desirable supplier behavior (e.g., Das et al., 2006; Lumineau & Henderson, 2012; Noordewier et al., 1990; Rivard-Royer, Landry, & Beaulieu, 2002). Based on a review of the literature, it is suggested that supplier relationship management has six different aspects: (1) *flexibility* of the supplier in quickly meeting hospital needs and changes in quantities of supplies ordered; (2) *assistance* that the supplier is willing to provide the hospitals in all matters related to the quality and quantity of supplies; (3) degree and intensity of *information exchange* between the supplier and the hospitals; (4) degree of *monitoring* required by hospitals to ensure that the supplier is responsive and is able and willing to supply the required quality and quantity of supplies; (5) *continuity expectation* referring to the hospitals' long term interest and orientation to maintain ties; and (6) *quality of supplies* that the supplier provides.
Internal lean practices	Aligned internal operations that help firms to perform effective medical procedures on patients in a timely manner at a reasonable cost (e.g., Alexander, Halpern, & Lee, 1996; Butler & Leong, 2000; Cook & Rasmussen, 2005; Goldstein, Ward, Leong, & Butler, 2002; Harper, 2002; Hay, 2003). Based on literature, it is suggested that internal lean practices have three characteristics: (1) p*atient and material flow management*; (2) *continuous quality improvement*; and (3) *waste management*.
Patient care quality	Excellence of the medical care received by patients in U.S. hospitals (e.g., Nelson & Niederberger, 1990; Van Ess Coeling & Cukr, 2000; Ware et al., 1983). Based on a review of the literature, it is suggested that patient care quality includes four primary dimensions: (1) *interpersonal quality* that reflects the relationship developed and the dyadic interplay that occurs between the healthcare team and patient; (2) *technical quality* that reflects the expertise, professionalism, and competency of the healthcare team in delivering the cure; (3) *environmental quality* that comprises hospital atmosphere related to cleanliness and tangibles, such as hospital bed and necessary equipment like drip stands and other required equipment for patient health needs; and (4) *administrative quality* that facilitates the production of the medical cure while adding value to the patient.

Figure 1. Conceptual Model



Framework of Key Relationships

Integrating the different departments and internal hospital entities would help the hospital know its stock positions and inventory requirements accurately thereby allowing the hospital to strategically source their inventory items in a planned manner from a few trusted suppliers, manage the procurement processes and govern the existing supplier relationships (Loh & Koh, 2004; Mettler & Rohner, 2009). Receiving up-to-date information on the hospital's inventory items would help the supplier increase its assistance to the hospital, which in turn would help improve its own flexibility to meet changing hospital needs for products (Coye & Kell, 2006; Wang, Tai, & Wei, 2006). It would improve the type and amount of information that the supplier could provide the hospital when requested (Pouloudi, 1999).

On the other hand, a technologically integrated hospital, like any other service firm, could become aware of the cost of purchasing items from each supplier (Das et al., 2006; Talluri & Sarkis, 2002) instantly, helping it choose its strategic suppliers for each of its products/services that are required by various departments. Collaboration between hospitals and their suppliers would increase the continuity expectations that both parties have of the relationship (Mettler & Rohner, 2009; Walshe & Smith, 2006).

In sum, a technologically integrated hospital that knows the latest information from all its internal elements would be able to manage its supplier relationships effectively (Das et al., 2006; Talluri & Sarkis, 2002) because suppliers would feel encouraged to perform better with a hospital that informs them about the required supplies quite in advance. Therefore, based on the above discussions on advantages of a technologically integrated hospital for supplier relationships, it is suggested:

P1: *Technology integration is positively related to supplier relationship management.*

As noted earlier, technology integration in a hospital internal supply chain could focus primarily on the electronic form of data exchange adopted for all daily communication between the different entities within a hospital (S. Li & Lin, 2006). A technologically integrated hospital

could spur effective inventory monitoring and control by all entities in-house in order so as to ensure that they have adequate supplies (e.g., blood units, counseling professionals, therapy professionals, medicines) at all times. In-house inventory monitoring at different supply chain entities could help reduce the hospitals' emergency buffer stocks and help them implement a lean system (Leidner et al., 2010) based on frequent but smaller delivery lots from suppliers.

Technology can help hospitals strategically plan the usage of their critical resources such as operating suites, intensive care units (ICU) and labs, various sophisticated medical equipment like magnetic resonance imaging (MRI), computed tomography (CT) scan and X-rays, considering the maximum and mean patient volumes and flow rates for each medical treatment process (Vissers & Beech, 2005). Thus technology could be used to maintain smooth patient and material flow rates in the hospital. A fundamental redesign of healthcare processes that is based on the use and integration of electronic communication across different technology platforms is now being implemented in some hospitals (Demiris et al., 2008).

Continuous quality improvement (CQI) adoption is facilitated by information systems, flexible use of personnel, and team support as well as training for managers (Lucas et al., 2005). Investing in medical technology does not automatically result in a significant improvement in patient care quality but organizational cooperation, workforce development and process analysis help improve the quality of health services (L. X. Li, 1997). Information technology such as using electronic patient record system and bar coding medicinal administration (Abrahamsen, 2005) can support all logistics and quality improvements in healthcare (Ammenwerth et al., 2002). Information technology can provide timely and accurate patient data and medical knowledge to the doctors and nurses who need it (Ammenwerth et al., 2002).

Lean philosophy strives to balance the demand for patient care with the capacity of the hospitals in order to eliminate wastes such as over-capacity or waiting times (Kollberg, Dahlgaard, & Brehmer, 2007). Healthcare requires innovation to remain competitive and cost efficient and lean implementation is a way to introduce incremental innovation in hospitals (de Koning, Verver, van den Heuvel, Bisgaard, & Does, 2006). Lean principles need to be applied to all processes to reduce all operational inefficiencies and reduce all types of wastes. Organizational information systems help in the distribution of the required information to different departments for lean implementation (de Koning et al., 2006).

Based on successful technology integration in hospitals (Stratman, 2008) and supported by IPT (Davenport, 1998; Galbraith, 1973; Tushman & Nadler, 1978), it is suggested that better information exchange would ultimately result in hospitals become lean. This is possible because better information exchange would benefit hospitals in optimizing their purchases as they can compare the product price and quality information available from each supplier and each department can buy the necessary quality products at lowest prices. In turn, it would provide the most appropriate medicines and other required supplies to the patient, keeping both the overall cost and time taken for delivery under control, helping hospitals become lean in the process. Therefore, based on the above discussions, the next hypothesis is offered:

P2: *Technology integration is positively related to internal lean practices.*

Both the supply and demand for hospital services need to be balanced for any hospital to function well. The preparation of the initial diagnostic and consultation report by the physician, taking the patient to the emergency room (ER) department (if it is an urgent case) and transferring the patient to specialized medical suites such as the operating room (if the patient needs surgery) are some of the internal supply chain related activities. The demand related activities incorporates processes for managing the flow of patients (Heineke, 1995) with the aim of having no more than the maximum number of patients that the hospital can handle. Failures in patient and material flow in the hospital such as excessive patient wait for admission

and medical procedures may have a direct negative impact on the quality and overall effectiveness of service performance (Baltacioglu et al., 2007). The strength of its supplier relationships is positively related to the patient and material flow in a hospital and its ability to serve patients.

Similarly, supplier relationship management also impacts the continuous quality improvement efforts at the hospital (McLaughlin, McLaughlin, & Kaluzny, 2004). Having structured relationships with hospital suppliers is one of the characteristics of a successful CQI implementation (LeBrasseur, Whissell, & Ojha, 2002). In addition to strong leadership support and commitment, successful and sustained CQI initiatives require hospitals to develop long term and mutually beneficial partnerships with key suppliers (LeBrasseur et al., 2002). Relationships with suppliers are necessary for hospitals to reduce their inventory and yet meet their patient care service quality standards (Dahlgaard, Pettersen, & Dahlgaard-Park, 2011).

Lean waste management can be successful only if hospitals are able to implement a "pull" system for managing their entire inventory (Womack & Jones, 2010; Zidel, 2006) which, in turn, depends upon supplier cooperation (Dahlgaard et al., 2011). Hospitals need to implement effective material restocking processes that involve more frequent but smaller batch deliveries or to rotate their supplies more quickly to reduce the amount of space used up in internal warehouses and the cash related to their tied-up in inventory (Graban, 2011), both of which could involve major supply chain improvements.

As noted earlier, lean systems theory (Flynn, Sakakibara, & Schroeder, 1995; Kaynak, 1997, 2002; Monden, 1981; Ōno, 1988; Shah & Ward, 2003; Sugimori et al., 1977) emphasizes that firms must have reduced inventory available just in time when they need it, and it requires supplier collaboration to implement such a "pull" system. Healthcare literature also supports this assertion (Dranove & White, 1987, 1989; Schneider & Mathios, 2006). Based on the above discussions, the next hypothesis suggests:

P3: *Supplier relationship management is positively related to internal lean practices.*

One of the objectives of lean implementation in a firm is to have high product or service quality (Dean Jr & Snell, 1996; Fullerton & McWatters, 2001) that meets or exceeds the required standards of the industry. Lean systems theory (Flynn et al., 1995; Kaynak, 1997, 2002; Monden, 1981; Ōno, 1988; Shah & Ward, 2003; Sugimori et al., 1977) highlights that reducing wastes would help firms identify and eliminate scrap and rework from their goods production or service generation processes. Lean systems theory helps explain the relationship between internally implementing lean practices at hospitals and the positive effect on patient care quality.

To deliver high PCQ the practitioners, i.e., both physicians and nurses need to master two aspects of medical care. First, practitioners need to become experts in the technical quality of patient care (i.e., the medical diagnosis and cure procedures and treatments need to be accurate and most effective). Second, the healthcare team members need to learn the attributes of interpersonal quality of patient care, i.e., keeping the patient well informed about the required medical treatment and its side-effects, empathizing with patients so that they are not overly worried (Hudelson, Cleopas, Kolly, Chopard, & Perneger, 2008; Marley, Collier, & Meyer Goldstein, 2004).

Hospitals should treat only the number of patients that they can handle so that patients flow though the hospital is effectively managed (Heineke, 1995). Smooth material and patient flow in the hospital help decrease the average wait times for patients before their surgery or other medical procedures (Baltacioglu et al., 2007) by ensuring that appropriate medical equipment and supplies and suites like intensive care units (ICU)s are available when needed. Longer wait times add additional stress to patients (Paterson et al., 2006), complicate patients' ailments, cause additional medical procedures to be performed on patients, and sometimes may

result in preventable outcomes like death (Derlet & Richards, 2000). Patient and material flow are related to both the interpersonal and technical aspects of PCQ.

As noted earlier, physical elements of a patient's environment such as the hospital bed, clothes and equipments must be fully clean and disinfected (Aiken, Clarke, & Sloane, 2008) in order to prevent infections (Pittet et al., 2000). Support from the administrative departments of a hospital such as billing and reception are also crucial to improving PCQ (Bokar & Perry, 2007; Conway, 1997). Implementing lean principles in a hospital encourages all practitioners to continuously develop expertise in their own areas of work, and to collaborate and share their knowledge with others in the healthcare teams (Sui-PPheng & Khoo, 2001), because value addition (Joosten, Bongers, & Janssen, 2009) and waste reduction (Toussaint & Berry, 2013) are two important concerns in a lean implementation. Thus, CQI and waste reduction, which form two pillars of a lean philosophy, are positively related to the technical, environmental and administrative dimensions of PCQ. Therefore, based on the above discussions, it is suggested that lean implementation in hospitals is positively related to all four dimensions of PCQ. Hence, the next hypothesize notes:

P4: *Internal lean practices are positively related to patient care quality.*

DISCUSSION AND CONCLUSION

In this conceptual paper, we suggested that a supply chain perspective is imperative to solving many problems U.S. hospitals face today because they arise within as well as beyond hospital boundaries. Based on tenets of lean systems theory, we offered three propositions that are concerned with the internal as well as external hospital supply chain. There are several direct and indirect implications of our conceptual framework for healthcare research and for hospitals and medical practitioners. We highlighted how a unified healthcare supply chain theory could be developed by integrating the different elements of the internal and external hospital supply chain, keeping the hospital at the center and the improvement in the quality of care received by admitted patients as the objective.

Our conceptualization targets some limitations of current conceptualization of PCQ. Most of the commonly used "hard" measures are disease or ailment-specific and reflect only specific aspects of quality of medical care administered in the hospital. Two common quality metrics available in the public domain are the 30-day risk-standardized mortality and readmission rates for ailments such as acute myocardial infarction (heart attack) and pneumonia. In addition, the Agency for Healthcare Research and Quality (AHRQ) reports patient safety indicators (PSI) for death among surgical in-patients with serious treatable complications. Many studies use CMS measures such as central line-associated bloodstream infections (CLABSI) in ICUs only or the surgical site infection from colon surgery. While using such detailed and specific measures are good to adequately know the extent of a specific outcome such as hospital-acquired infection, even a bunch of these detailed measures would not adequately reflect all dimensions of care quality, especially the interpersonal, environmental or administrative dimensions of PCQ. There are not too many healthcare studies that have considered attributes drawn from overall comprehensive and holistic consideration of both internal and external aspects of the hospital supply chain.

We believe that the broad conceptualization of a hospital supply chain offered in this paper could help spur empirical studies testing our propositions. Healthcare studies may benefit from including factors that are beyond the immediate control of the hospitals, such as their equipment and medicine suppliers and even other entities in the different layers of the external supply chain such as the insurance providers. With this paper, we have attempted to take the first step towards building a unified supply chain theory for healthcare with the research context limited to a hospital-centric view of the supply chain keeping admitted patients at the center.

Implementing lean practices in the hospital is the immediate objective while having high care quality available to admitted patients is the ultimate goal of our proposed framework

Based on several recent papers from interdisciplinary fields and status reports from the business press on the state of the U.S. healthcare referenced in this research, it is evident that poor quality of patient care is the main issue troubling U.S. healthcare. As noted by Boyer and colleagues (2012), the IOM report (Kohn, Corrigan, & Donaldson, 1999) has already prompted some corrective action in the healthcare community with many scholars working to improve various quality aspects of the system but several issues still remain unresolved. The framework presented in this paper attempts to offer a more comprehensive perspective of the patient quality issues being faced at most full-service U.S. hospitals than found in the literature. Specific propositions, supported by extant literature and theory, are advanced for relationships among the variables. This research contributes to the growing literature positioned at the cross-section of OM and health care management (HCM) fields in the following ways.

First, this research offers an integrative approach to resolving the major issues in U.S. healthcare by drawing in variables from both the internal as well as external supply chain of a typical U.S. full-service hospital. Using a lean supply chain perspective, this research offers a framework to suggest how the quality of care received by patients can be improved. It is thus an attempt to offer an integrated approach to resolving healthcare issues. The results of this study highlight relationships between the different constructs that have been overlooked in the operations and healthcare literature (such as the role of supplier relationship management on internal lean practices in healthcare or the role of healthcare team effectiveness on quality of patient care) (Bohmer, 2009; Schneller & Smeltzer, 2006; Toussaint & Berry, 2013).

Second, as discussed in SCM literature (see Caniëls & Gelderman, 2007; Das, Narasimhan, & Talluri, 2006; Goodman & Jones, 2013; Mettler & Rohner, 2009; Noordewier, John, & Nevin, 1990; Olsen & Ellram, 1997; Rivard-Royer et al., 2002; Spekman, 1988; Stuart, 1997), the framework highlights that effective supplier management is very important for hospitals, like for other service firms (Handfield, 2010). Hospitals may need to pay attention to all the six different aspects of supplier relationship suggested in this study–supplier flexibility, supplier assistance, supplier information exchange, supplier monitoring, continuity expectation, and quality of supplies–to ensure that they have the best cooperation from their suppliers.

Third, the framework being offered here integrates several constructs that have been mentioned in an isolated manner across several studies in the fields of HCM and medicine (see Bohmer, 2009; Schneller & Smeltzer, 2006; Toussaint & Berry, 2013; Weintraub, 2011). Many HCM studies do not consider all the aspects such as patient and material flow, continuous quality improvement and waste management while discussing lean implementation in hospitals. From an HCM perspective, the framework highlights that hospitals may need to consider all three characteristics of lean implementation. This study attempts to include different aspects of patient care quality in a more comprehensive manner and future HCM studies may find it beneficial to use such a measure.

Finally, our framework has several implications for U.S. hospital administrators and other medical practitioners. To maximize the positive effect of the internal implementation of lean practices on quality of care delivered (Dobrzykowski, McFadden, & Vonderembse, 2016); hospitals could focus on all three different aspects–material flow management, continuous quality improvement and waste management. Patient and material flow management refer to the hospital following efficient patient admission and discharge procedures. Although many hospitals in the U.S., especially in larger cities, may already be using emergency and operating room scheduling software, not all hospitals use such advanced scheduling systems (Bodenheimer & Pham, 2010; D. Gupta & Denton, 2008; Zaghloul & El Enein, 2010). We suggest that hospitals may need to use room scheduling systems which specifically factor in the patients' medical conditions and needs and match them with the hospital room and equipment

availability information together so that both patient and material flow within the hospital are streamlined.

Continuous quality improvement considers whether healthcare teams internalize the lessons learnt from past mistakes on patient safety so as not to repeat them. Many hospitals may already be using operational data from electronic clinical information systems such as electronic health records (EHR) platform to plan its staffing of doctors, nurses and other employees. However, scholars have mentioned that the smaller and rural hospitals have still not caught up with EHR (C. Chen, Garrido, Chock, Okawa, & Liang, 2009; Graetz et al., 2014; Jha et al., 2009). Further, many hospitals are not using up-to-date advanced medical equipment and newer technologies such as using electronic aspirin, needle-free care for diabetes (MacRae, 2013) or using advanced robotics to assist the complicated surgeries even if it is justified for the patient's medical condition (Albani & Lee, 2007; Gomes, 2011).

Waste management refers to whether hospitals use a ''pull'' production system wherein all supplies are inventoried as and when required, and whether hospitals push suppliers to achieve shorter lead-times for delivery. Hospitals need to streamline their own ordering, receiving and other paperwork from suppliers all items, especially their emergency medicinal stocks. Hospitals may need to better train all their healthcare teams to optimally use all medical consumables so as to eliminate wastes (Hirano, 1995; Wakefield et al., 2005).

Hospitals need to ensure that both patients and the required materials and supplies flow smoothly throughout the hospital and are available when needed at the appropriate place. Sometimes patient surgeries are delayed because of lack of available operating rooms, appropriate doctors, anesthetists and even due to a lack of appropriate medicines or the correct medical equipment (B. Gupta, Agrawal, D'souza, & Soni, 2011; Kumar & Gandhi, 2012; Wong, Khu, Kaderali, & Bernstein, 2010). Further, hospitals need to use a lean orientation to identify wastes and delays that do not add value to the patient or hospital and eliminate such activities (Graban, 2011; Toussaint & Berry, 2013).

REFERENCES

References available upon request.