



Contents lists available at ScienceDirect

Technological Forecasting & Social Change



Healthcare supply chain management; strategic areas for quality and financial improvement

Ik-Whan G. Kwon^{a,*}, Sung-Ho Kim^b, David G. Martin^c^a Center for Supply Chain management Studies, Saint Louis University, United States^b Supply Chain Management, Saint Louis University, United States^c Ansell School of Business, Western Connecticut State University, United States

ARTICLE INFO

Article history:

Received 17 November 2015

Received in revised form 5 July 2016

Accepted 7 July 2016

Available online xxx

Keywords:

Quality care

Supply chain principles

Healthcare supply chain innovation

Collaborative Planning and Forecasting

Replenishment (CPFR)

Cross-docking

Process improvement

Business analytics

Vendor Management Inventory (VMI)

Financial impact of supply chain management

ABSTRACT

Healthcare supply chain has recently attracted attention by scholars, researchers, government officials and providers as one of the main tools in their effort to manage healthcare cost and improve quality at the same time (Elmuti, et al., 2013). It is reported that healthcare costs in the United States represent a sizeable portion of the gross domestic product and it is expected to increase at a much higher rate than other sectors in the economy. Nevertheless maturity of healthcare supply chain is said behind the commercial supply chain leaving room for improvement (de Vries and Huijsman, 2011). This paper explores strategic areas where healthcare supply chain may enhance efficiency in terms of cost per patient discharge of healthcare operations while improving the quality of care in terms of reducing re-admission rate. This paper argues that fundamentals of supply chain principles should be deployed to create “supply chain community surplus” where resources can be tapped to improve quality of care. Three strategic areas were explored to maximize the provider’s revenue; understanding of supply chain principles (perception change), process improvement and deployment of logistics tools.

© 2016 Elsevier Inc. All rights reserved.

1. Introduction

As early as 2008, the Pricewaterhouse Health Research Institute reports more than \$1.2 trillion out of \$2.2 trillion spends on healthcare each year is a waste of money (Kavilanz, 2009). Failure of using standardized process costs the healthcare industry unnecessary waste (Dooner, 2014). A lack of cooperation from health care supply chain partners is cited as a major barrier in implementing cost effective standardized process in the healthcare industry (Nachtmann and Pohl, 2009). Lack of cooperation may stem from either a lack of or absence of collaborative framework among trading partners. As a matter of fact, Nachtmann and Pohl (2009) points out that 60% of survey respondents mentioned a lack of trust is a major barrier in achieving an acceptable level of collaboration among healthcare supply chain organizations.

In spite of many studies claiming that use of supply chain tools reduce organizational costs, reduce cycle time and lead to higher performance without compromising quality (Elmuti, et al., 2013), the healthcare industry consistently lags commercial industry in implementing supply chain tools. For example, the healthcare industry

still uses heavily less than truck load (LTL) transportation mode (60% of their transportation) which is more expensive and increase damages as it touches more frequently than truck load (TL) mode. The warehouse utilization rate in healthcare is 60–70% of the capacity and inventory turns in healthcare is 2 whereas it is 44 for consumer electronic, 10 for automotive industry and 6 for consumer packaging goods (Dooner, 2014). Such an inefficient utilization of capital investment in inventory management only adds to the operating costs in the healthcare industry. According to one study, the logistics cost in healthcare is 38% of the total expense while the same is 5% for the retail industry and 2% for the electronic industry (Johnson, 2015). A possible reason for such a wide gap may include unique distribution networks that healthcare supply chain is employing due to group purchasing organizations (GPOs) and independent delivery networks (IDN) practices (Kwon and Hong, 2011). A recent study reveals that healthcare cost in this country is the biggest barrier to entrepreneurship investment (O'Marah, 2015).

Another area that healthcare supply chain is struggling with is a misunderstanding of the fundamentals of supply chain concepts. Healthcare supply chain has been mistakenly identified as purchasing and contract management as group purchasing organizations such as Novation and Premier dominate purchasing and contract management for providers. Recent information indicates that over 70% of healthcare

* Corresponding author.

E-mail addresses: kwoni@slu.edu (I.-W.G. Kwon), sunghokim@slu.edu (S.-H. Kim), martindg@wcsu.edu (D.G. Martin).

spends is managed by GPOs. Their major role is to negotiate the best prices for healthcare providers and pay less or no attention to logistics related cost of the total package. Supply chain is more than purchasing and contract management. Nevertheless, the term “supply chain management” is often used by healthcare professionals without having a firm concept of this management tool. Often cited excuse is that “the hospital stands for humanitarian delivery of health care than cost containment” (Schneller and Smeltzer, 2006). It has become a function, not an end-to-end process (Cecere, 2014). A failure of understanding of supply chain principles may have led decision makers to narrowly defined supply chain concept (e.g. purchasing) leaving many other areas in supply chain unexplored or neglected resulting in suboptimal solutions. We submit that it is time to integrate commercial supply chain concepts with healthcare supply chain practices to reap potentials from supply chain operations.

The purpose of this paper is to explore and discuss strategic areas of supply chain in healthcare organizations in an effort to reduce spending (efficiency) and improve quality of care (effectiveness) within a supply chain management framework. This paper argues that efficiency and effectiveness coexist in supply chain as it creates supply chain surplus where extra resources so created will be diverted/reinvested into areas which benefits customers (patients). Strategic areas proposed in this paper will be divided into three broad fields; deeper understanding of supply chain concepts in healthcare, organizational process improvement and utilization of relevant supply chain functional tools.

This paper is organized as follow: Section two will briefly review literature in healthcare supply chain areas relevant to supply chain foundations and tools deployed in commercial areas. Section three discusses strategic areas where supply chain management tools can make the difference in improving the operational outcomes. Section four discusses conclusion and summary and managerial implications. Limitations of this paper will be presented in Section five.

2. Existing literature on healthcare supply chain management

Although the concept of supply chain management has been around for over 20 years, still there are many professionals who believe that supply chain is a simple tool that can be adopted and implemented without solid foundation and framework of how supply chain works. Perhaps that is one of the main reasons why in some areas especially in healthcare, supply chain implementation either failed or produced less than expected. Many professionals rush to the concept of supply chain in order to reap an outcome that supply chain management promises to yield only to be disappointed (Benavides, et al., 2012).

Supply chain indeed provides intended results, un-precedent to other management tools. However, supply chain management whether it is a long term strategic tool, or operational as well as a tactical tool, should be deeply rooted in three principles; sharing information, sharing the risks and benefits (Kwon, et al., 2011). Absence of any one of these principles may result in a suboptimal performance.

Sharing information has been one of the most crucial and challenging elements in the supply chain success story including or perhaps more importantly in healthcare supply chain since healthcare supply chain deals with critical services and products that impact human life. Information sharing fosters a spirit of collaboration and provides supply chain practitioners with opportunities to optimize the entire supply chain operation, not one area of their interests (Kwon and Suh, 2004a, b). Sharing information is likely have a potential disruptive impact on existing supply chain structure that might have been one of the major causes that collaborative consumption is not well understood in healthcare supply chain field (Barnes and Mattsson, 2016). In addition, knowledge sharing even foster innovative capabilities among trading partners. (Schneckenberg, et al., 2015).

A close collaboration based on supply chain principles tends to reduce transaction costs which, according to many studies, represent as much as 35 to 40% of the costs associated with economic activities

(Butler, et al., 1997; North, 1990) and as high as 50% in IT outsourcing (Rottman and Lacity, 2006). One research shows a strong relationship between the level of trust and productivity ($r = 0.66$, Dyer and Chu, 2003), and Chrysler lost \$24 billion for lack of collaboration between Chrysler and suppliers over 12 years period (Henke, et al., 2014; de Vries and Huijisman, 2011).

Enduring relationship between supply chain partners reduces search and review/inspection costs contributing to increase profitability for the entire supply chain partners. Healthcare supply chain partners consider the “pie (profit)” is fixed that result in an antagonistic negotiation behavior among supply chain partners. Supply chain practitioner believes “my supply chain is as strong as my weakest link” (Coleman and Jennings, 1998) and renders a helping hand to its partners to increase the “pie” for everyone involved in business transactions since supply chain is a competitive strategic advantage. Power of collaboration has been also reported in manufacturing and information technology fields. For example, Lin, Wu and Cheng (2015) argue that such collaborative effort produced significant positive effect on product quality, reduction of design changes, cycle time and overall cost.

Although healthcare supply chain has come a long way to recognize contributions that other sectors in supply chain make in the areas such as product design, transportation, inventory, warehousing, packaging etc., still the dominant player in healthcare supply chain is contract management via group purchasing organizations. In spite of pioneering works by Burns (2002), Schneller and Smeltzer (2006) and others (Dacosta-Claro, 2002; Oliveira and Pinto, 2005) in health care, progress has been painfully slow in implementing the supply chain strategies to the entire healthcare supply chain arena. There has been little progress made in exploring various tools available in the commercial areas in the healthcare field in spite of the fact that there are billions of dollars in value to be realized in healthcare industry by utilizing supply chain tools in the entire healthcare operations (Harrington, 2015).

Kwon and Hong (2011) discussed how two supply chains differ in emphasis which may provide a framework for further research. Among the areas, they highlighted four critical supply chain spots that would improve performance in healthcare supply chain management; core emphasis (efficiency for commercial vs. effectiveness for healthcare), supply chain plan (push/pull for commercial vs. mostly pull for healthcare), scope (entire supply chain for commercial vs. regional/local/providers for healthcare) and sourcing (common practice for commercial vs. seldom practice in healthcare supply chain). Among many areas that healthcare supply chain could explore to improve profitability, the above four areas are most promising to achieve the goals in healthcare operations; enhance profitability while maintaining quality of healthcare delivery.

It is worth exploring how much progress has been made in healthcare supply chain in a few important areas since Burns' work in 2002. Table 1 below is reproduced from Burns' original work (2002) with perceived progress that has been made since then.

There is growing evidence that healthcare supply chain is moving toward their target area other than “service” area. A considerable effort has been made by a few healthcare organizations to consolidate the logistics component of supply chain (e.g. ROi in Missouri and Inter-mountain Healthcare System in Utah). Titles such as supply chain manager, vice president of supply chain, etc. in healthcare organizations become more prevalent now than even 5 years ago. One study shows that 62.5% of companies had their Head of supply chain on the Operational Board or Executive Management Team (Farrow, 2013).

Nevertheless, the predominant operational model in healthcare supply chain is still “pull” model as a coherent planning and forecasting concept is not a part of their strategic business plan. As a result, inventory is overstock, becomes obsolete and puts pressure on supply chain cost. Considering supplies are the second largest expenditure after personnel, waste could have been minimized by a sound planning and forecasting in mapping the entire supply chain. Commercial supply chain effectively utilizes push-pull boundary to optimize the entire

Table 1
Areas of emphasis between two supply chain operations with progress made since 2002.

Attribute	Commercial supply chain	Healthcare supply chain	Perceived progress as a percent of commercial supply chain ^a
Target area	Products Oriented	Services oriented	60 (still contract mgt.)
Major emphasis	Efficiency	Effectiveness	50 (efficiency is limited)
Supply chain model	Push/Pull	Mostly pull	50 (planning and forecasting are still in its infancy)
Quality	Important	Critical	100
Scope	Global	Regional/local	30 (supply chain is limited to hospital/healthcare units)
Sourcing	Prevalent	Difficult/impossible	20 (sourcing almost non-existence)
Payments	Consumers	Third parties	20 (by nature of business, consumer is less involved)
Regulations	Less	Heavy	100 (too many regulations may have stymied supply chain implementation)

^a The assessments in this table are based on literature findings from various research publications.

supply chain inventory. Healthcare supply chain limits its scope to its own silo areas (primarily purchasing). As a result, hospitals are missing the opportunity to reap benefits from supply chain surplus that commercial supply chain routinely expects to achieve.

If the healthcare supply chain development stage is to be compared with that of commercial supply chain using SCMR/CSC model, we would argue that the healthcare supply chain is in Level No. 2 (few units in hospital involvement) while the commercial supply chain is in Level No. 4 (several external partners involvement) in Schneller & Smelter model (Schneller and Smeltzer, 2006). Level 2 in the Model means that a healthcare provider is concerned with managing and monitoring operational supply support which is characterized by little integration among units, little transparency on data related to spending and a low level of price and cost metrics. Level 4 means supply chain value integration and is characterized by system level value enhancement, system-wide policy formulation, long-term value metrics, etc. As the level of sophistication improves, revenue increases and costs decrease, creating opportunities for sustainable growth with patient quality improvement as a by-product.

3. Supply chain surplus and quality care

The nexus of supply chain management is to improve operational efficiency while enhancing responsiveness to customers (patients). Supply chain principles call for optimizing its operations throughout the supply chain arena and create an environment where supply chain surplus can be created. Evidence shows supply chain indeed creates surplus for the entire supply chain operations (Duffy, 2009; Poirier, et al., 2010; PRTM, 2010). The extra gain in resources released from cost optimization can be diverted into patient quality improvement and other innovative investments where further efficiency and quality improvement can be pursued. Additional investment into innovative venture further enhances provider's brand equity that further attracts additional customers (patients). The preceding argument contains a practical implication in that the healthcare providers now are in a position to improve quality care without transferring resources from other important strategic areas. Supply chain implementation allows the providers to execute two seemingly contradicting objectives (efficiency and responsiveness) with measurable and positive outcomes.

3.1. Supply chain tools in health quality perspective

There are several supply chain tools that have been extensively deployed in the commercial supply chain. We highlight here three tools pertinent to healthcare supply chain optimizations target; reducing operating costs and improving patient quality cares which includes; supplier relationship management (SRM), logistics tools and process improvement.

3.1.1. SRM

SRM is a philosophy of mutual respect and collaboration between a company and its suppliers manifested by co-prosperity that can deliver value for both parties. Group purchasing organizations (GPOs) and

independent delivery networks (IDNs) dominance in procurement and contract management in healthcare providers leave little or no rooms for providers to develop supplier relationship management that has been a key management philosophy in commercial supply chain. A substantial and growing body of evidence attests the simple fact that buyers are beginning to understand the value of enhanced relationship with their suppliers (O'Brien, 2014). End-to-end collaboration with suppliers is credited to saving from 10% (automobile) to 20% (consumer and electronic goods) from the base line in inventory (Duffy, 2009). Chrysler lost \$24 billion profit over past 12 years due to lack of supplier relationship management (Henke, et al., 2014). A study indicates that improved relationship leads to cost reductions and cost prevention, improved quality, delivery performance and enhance innovation (Kumar, 2004; Sander, 2015).

SRM is a reaction to a traditional negotiation tactics between suppliers and buyers that existed for many years targeting only short term financial gains. Traditional bargaining tactics have been characterized as combative strategy whereas in supply chain, it is perceived as a collaborative roadmap. Traditional bargaining strategy considers the process is a zero-sum-game while SRM considers negotiation as value-added strategy for mutual growth as shown in Table 2.

SRM encourages proactive engagement with their strategic suppliers to capture innovation leading to new products in healthcare, and speed up time to the healthcare market place thereby improving patient care. If properly executed, SRM creates an environment where supplier keeps capacity dedicated to the providers (no stock out), sets aside dedicated personnel to work directly at the provider's facilities (less opportunity supplying wrong products), commit investment in new equipment that benefits only the providers (exclusive new product design for partner), provides exclusive use of new technology developed by the supplier (Innovative opportunity), holding inventory to support the provider's needs (reducing inventory cost), provide direct financial support if needed (financial gain in the market) and create information technology systems unique to business with the providers (sharing IT development cost) (Trent and Zachria, 2012).

Research shows that adoption of SRM produces tangible results. For companies which initiated SRM, the average lead time from suppliers is 6 days where the same for companies without SRM initiatives is 20 days (Spiegel, 2011). Other studies report differences of performance

Table 2
Bargaining approach between two models.

Traditional approach	SRM/Supply chain approach
Extended payable	Reduce waste and network total cost of ownership
Combative negotiations	Reduce inventory
Insist harmless clauses	Reduce lead-time and enhance flexibility
Transferred warranty obligations	Improve manufacturability and design
Imposes performance fines	Accelerate continuous improvement
Extract concession	Increase speed to market
Redundant audits	Advanced innovation

Source: Sander (2015, p. 22).

improvement between SRM adopters and non-adopters in other key areas; lower price (23% vs.13%), on-time delivery (23% vs.11%), quality improvement (21% vs. 5%), and services improvement (21% vs. 17%) (Anderson Group, 2005). A recent study even argues that a practice of SRM saves auto industry over \$2000 per car during 2001 to 2013 period (John, 2014) In healthcare, it has been either a very slow process or almost non-existent in adopting SRM concepts since decision makers in healthcare providers are far removed from the relationship building process with suppliers as GPO almost always monopolizes the negotiation process with suppliers.

3.1.2. Logistics in healthcare industry

Logistics in the healthcare industry is behind commercial areas for many years. Healthcare providers do not see any compelling reasons to optimize logistics cost as GPOs dominate transactional as well as the operational side of logistics operation (Kwon and Hong, 2011). Transportation and inventory costs in supply chain are major component of overall supply chain cost (\$1.45 trillion, 8.3% of GDP in 2014) (CSCMP, 2015). Nevertheless, decision makers in the healthcare industry have not paid much attention to these areas. As a result, logistics cost per transaction in healthcare industry is higher than in the commercial supply chain areas. Selection of the transportation mode in healthcare industry is consistently subpar compared to commercial supply chain (LTL vs. TL). The warehouse utilization rate in healthcare is 60–70% of the capacity and inventory turns in healthcare is 2 whereas it is 44 for consumer electronics, 10 for the automotive industry and 6 for consumer packaging goods (Dooner, 2014). Such an inefficient utilization of logistics assets only adds to the operating costs in the healthcare industry. According to one study, the logistics cost in healthcare is 38% of the total expense while the same is 5% for retail industry and 2% for the electronic industry (Johnson, 2015).

A proper deployment of selected logistics tools certainly reduces supply chain costs which, in turn, contributes to overall healthcare cost reduction. According to one study, a use of logistics tools saves 6 to 13.5% in procurement cost, 2% to 4% in demand fulfillment, 2.5% to 4% in order management, 0.5 to 2% in supplier management, 0.5% to 1.5% in logistics management, and 0.5% to 1.5% in inventory management (Pricewaterhouse Cooper, 2008). Cost saving from the logistics area could be used for patient quality improvement field. In spite of mounting evidence, the healthcare supply chain has been slow in implementing some of the promising logistics tools that commercial supply chain has been using for decades. This paper explores a few here.

3.1.2.1. Vendor management inventory (VMI). VMI is one of the many inventory management tools based on collaborative spirit between manufacturers and distributors, between distributors and wholesalers and between wholesalers and providers. VMI is a means of optimizing supply chain performance in which the manufacturer is responsible for maintaining the provider's inventory level. The manufacturer has access to the provider's inventory data and responsible for generating purchase order. The ownership of inventory under VMI remains as under a typical business model.

VMI has a set of rules and process (13 steps; www.vendormanagementinventory.com) and it has shown as a very effective and promising inventory management tool. VIM was originated out of mis-management of inventory; almost 50% errors in inventory management stems from either error in hospital ordering (34%), or error in provider forecasting (13%). Since manufacturers are in control of inventory management, VMI reduces data entry error (main sources of forecasting errors), improves service levels (almost no stock-out) and opens up a true partnership opportunity between providers and suppliers. For manufacturers, VMI tends to improve the fill rate for providers (thereby improving lead time), ordering costs will be reduced and overall service levels will be improved. Overall supply chain cost will be reduced thereby releasing resources for investment in other critical area such as patient quality improvement.

3.1.2.2. Cross docking (CD). Cross-docking is a process where a product is received in a facility, occasionally married with other products going to the same destination, then shipped at the earliest opportunity with outgoing into a long-term storage. Cross-docking shifts the focus from supply chain to demand chain thereby reducing uncertainty/variability since goods coming to cross-docking center have already been pre-allocated against a replenishment order generated by a provider in the supply chain. Cross-docking functions as coordinating points rather than storage point. This tool is especially beneficial for small independent providers that do not have enough quantity to qualify for low transportation rates between manufacturers/ suppliers and providers.

According to one study, the three biggest reasons for using cross-docking are improved service level (23%), reduce transportation cost (17%) and reduce the need for warehousing space (14%) (Saddle Creek Corporation Report, 2009). Wal-Mart, for example, delivers about 85% of its goods through cross-docking facilities while the industry average is about 55%. However, it should be pointed out that cross-docking has its own challenges. Inadequate information system may hinder efficient and effective operations of cross-docking. It requires advanced knowledge of the inbound product, its destination, and a system for routing the product to the proper outbound vehicle. It is suggested that ideal candidate products for cross-docking are; most popular (high demand) and highly predictable (less demand variation) and high volume (truckload type), such products as exam gloves, textiles, surgical gowns, IV tubing and copy paper. In addition, an extensive use of cross-docking creates less opportunity for forming a sustainable relationship with manufacturers thereby little or no room for a forming sustainable relationship with their customers.

3.1.2.3. Collaborative planning and forecasting replenishment (CPFR). This tool has been rarely used by many organizations in general and healthcare providers in particular as it requires a vigorous process requirement to realize intended results; increase inventory turns and improve patient care. CPFR is a collaborative technique that formalizes the process between two trading partners agreeing upon a joint business plan and forecast, monitoring success through replenishment, and recognizing and responding to any exceptions. In a broad sense, it is about people, process, and technology (VICS, 2013). The purpose of CPFR is to convert the supply chain from a disjointed and inefficient forecasting push system to a coordinated demand driven pull system. It tries to minimize the impact of forecast error through supply chain collaboration between manufacturers and providers on one critical product (e.g. critical supplies for surgeries). Well designed and executed CPFR, therefore, can and will improve product flow, reduces lead time and total system inventory investment. (Seifert, 2003).

One study by Covidien in early 2000 illustrated superior performances in several key areas of supply chain operations. For Covidien, it took almost a year from the planning stage to implementation of CPFR with their major distributor. Once completed, the outcomes were very promising. Inventory turns increased by 41 percentage points to 16.6 which is not a surprise since one of the major reasons for CPFR is to optimize inventory level. As both parties become well settled in with mutually agreed levels of inventory, there is no reason to keep unnecessary amounts of inventory. As a result, the service level improved to 97.5%, an increase of 2 percentage points. Less chance of stock-out and improvement of service level pushed sales by 23% increase and overall excess assets decreased by 36 percentage points as there was no need for access warehouses and fleets of transportation¹.

3.1.3. Process improvement

Management of process improvement may lead not only to improved quality, but also to the creation of innovative business and new market opportunities. (Robinson and Malhorta, 2005).

¹ This information was furnished by Senior VP-Logistics at Covidien-Tyco Health as a part of her presentation on overall Covidien-Tyco Supply Chain Management in 2002

3.1.3.1. Standardization. Kavilanz (2009) estimated that \$1.2 trillion out of \$2.2 trillion on healthcare spending has been waste. Among many areas the study cited as sources of waste, a lack of standardized process is one of the areas that can be easily corrected and save resources. As early as 2000, Lacy (2001) argues that process improvement could save approximately \$16.5 billion in healthcare expenditure. Marino and Edwards (1999) estimated a 5% to 7% savings with an average standardization process and additional 5% to 7% savings with substitution programs. Process improvement and standardization in healthcare provider organizations is considered not too difficult and challenging. Standardization certainly reduces and in many instances eliminates duplicated processes within and across the system.

Standardization offers several advantages. First, it allows decision makers to easily estimate how much time and resources are needed to complete tasks. If a customer places a special rush order, there is no need to pull the best workers off other jobs to meet the demand. When work is standardized, every employee is considered his/her best on that task and assignment. Estimating what it takes to meet any requirement becomes a matter of simple computation (Ryder Supply Chain Solution, 2011). It is also reported that process standardization strengthens code of conduct especially auditors/inspectors/quality examiners (Korean Herald, 2007). Such effort can be easily understandable as standard input creates a benchmark, which in turn creates visibility to uncover waste and subsequent cost reduction.

3.1.3.2. Lean concept. The Healthcare industry is well situated with six sigma applications especially in clinical and patient improvement areas. Six sigma addresses variation reduction thereby improving patient care outcomes. However, six sigma alone cannot achieve total cost reduction as it leaves a large area in provider's operations where much waste still prevails. However, lean management has seldom been used in healthcare management yet and therefore will provide a great opportunity for further optimizing resources. Lean is a philosophy that shortens the lead time by eliminating waste thereby enhancing customer as well as shareholder value. Lean focuses on eliminating waste in new product design, manufacturing, transportation/warehousing, increases flexibility, and reduces cost. Lean involves using as little as possible of the available resource including time. Waste is a business process that does not create value and the customer does not want to pay for it.

The primary goal for lean application is to reduce waste in the healthcare delivery system. Many professionals mistakenly believe that six sigma practice alone reduces waste. Six sigma is a foundation of lean management. With six sigma, the process becomes stabilized where lean tools can be effectively applied. With unstable process, it is rather difficult to measure whether lean tools produce any expected results. It is important, therefore, to understand that there is a clear sequential link between lean and six sigma in the optimization process. On a healthcare supply chain management prospective, six sigma could help identify the root causes of variation in patient care management, while lean would contribute to lowering patient care cost thereby releasing additional resources for other innovative investment. For example, poor quality (six sigma) requires additional resources (cost), which tends to delay the speed of innovative investment elsewhere, which in turn may result in weakening the competitiveness in the market, and further erodes revenue and subsequent profit for the organizations.

Study shows that properly executed lean process produces measurable outcomes. According to one study, lean supply chain adopter achieved an average of 20.9 days in inventory vs. 35.4 days for non-lean adopter and 19.9 inventory turns vs. 10.4 for non-lean adopter (Vitasek, et al., 2005; Reeve, 2002). Although lean concepts produce very promising results in many areas especially the healthcare industry, it has several challenges. Many employers still believe that mass production process is the best way to lower cost based on a pure micro

economic theory. In addition, many people still believe that maintaining a more than optimum level of inventory is necessary to avoid unexpected demand, a sign of poor planning and forecasting process. A loyalty to current paradigms ("we have always done it this way") hinders any new innovative process improvement thereby perpetuating the existing inefficient process management. Finally, individual and not team recognition often creates a culture of "me, me" environment destroying the supply chain surplus that could be gained through a collaborative environment.

3.1.3.3. Business analytics. Flow of information is ever increasingly unmanageable as communication technologies becomes rapidly developing almost daily. The growth of digital technology has enabled providers to collect massive amounts of data and requires a new field of managing this massive data leading to useful information. Business analytics is one of the many responding to such needs.

Business analytics refers to the skills, technologies, applications and practices for continuous iterative exploration and investigation of past business performance to gain insight and drive business planning (Davenport and Harris, 2007; Watson, 2014). Business analytics focuses on developing new insights and understanding of business performance based on data and statistical methods. Since business analytics makes extensive use of data, statistical and quantitative analysis, explanatory and predictive modeling, and fact-based management to drive decision making, the outcome from this technique appears to be superior to other tools that many decision makers rely upon.

For example, Wal-Mart and Dell use this technique to simulate and optimize supply chain flow; reducing inventory and stock-out possibility. Novartis, Amazon, Caterpillar and Yahoo employ this tool to improve quality and product safety. H.D. Smith, a pharmaceutical company is using cloud analytics software to get a better handle on its supply chain, allowing it to slice and dice inventory by profit margin and customer as well as track the shipping route of prescriptions and health and other wellness products (Boulton, 2015). Users of this tool believe their competitive advantage has been improved (New Intelligence Enterprise, 2011). Users of this tool outperform in key financial metrics compared to non-users; 1.6 times better in revenue growth, 2 times better in EBITDA growth and 2.5 times better in stock price appreciation than non-users (IBM Center for Applied Insights, 2012). Another study reports that business analytics enable decision-makers to improve demand fulfillment by at least 10%, faster and more effective reaction time to supply chain issues (41%), and increase in supply chain efficiency of 10% or more (to 36%) (Accenture Global Operations: Megatrend Study, 2014). There is no evidence so far that the healthcare industry takes advantage of this emerging technique to make optimum decisions in resource allocations.

4. Managerial implications

For supply chain professionals in the healthcare industry, we need a new generation of supply chain professionals who are not exposed to pre-conceptual commitment that healthcare supply chain is different from the rest. Supply chain concepts and principles are identical whether it is applied to commercial or healthcare industries. The objective is to reduce operating costs and improve customer responsiveness thereby creating supply chain surplus where every participant benefits from being a participant of the supply chain community. We need innovative professionals from supply chain management degrees who are not afraid of trying new tools in the healthcare area. Once we overcome duplicitous concepts of supply chain, doors may open for a wide range of supply chain tools that have been successfully deployed and employed by commercial supply chain practitioners with measurable outcomes. The task is not an easy as the demand for supply chain professionals between 2010 and 2020 exceeds supply by a ratio of 6 to 1 (Craighead and Ruamsook, 2014) and there is a growing demographic gap in supply and

demand of supply chain talent as 25% to 33% of the supply chain workforce is at or beyond retirement age (Harrington, 2015).

5. Conclusions

This paper argues that supply chain management can and will improve efficiency (cost reduction) and improve patient care simultaneously by investing resources released from supply chain deployment to other innovative areas where patient care benefits without sacrificing resources for other areas. This paper introduced the basic concepts of supply chain management to healthcare management. Although healthcare supply chain has existed for sometimes, it has not been populated as much as it has in the commercial field. As a result, supply chain surplus and benefits from the healthcare area has not been as much as should be. This paper argues that professionals in the healthcare area ignore the fundamentals supply chain principles and false assumption that healthcare supply chain is different from the rest. Full benefits will be realized once healthcare supply chain professionals recognize and accept that supply chain fundamentals are and should be the same regardless of which industry we are deploying supply chain tools.

Three major strategic areas were highlighted and suggested for healthcare supply chain management to experience the maximum benefit from supply chain operations; supplier relationship management, logistics operational tools and process improvement. Each one of these tools has been extensively and widely employed in commercial supply chain areas for many years with measurable returns. Once healthcare supply chain professionals abandon the idea that some of the tools used in commercial areas cannot and should not be used in the healthcare industry because healthcare is “different” from others, the potential full benefits will be realized. A fundamental shift of mindset needs to be instituted in healthcare professionals to reap potential gains from this tool.

This paper has limitations in that it addresses only supply chain applications to the healthcare field on a conceptual basis with targeting quality improvement. No hypotheses were constructed and tested as the intention of this paper is to highlight some of the supply chain tools that have been used in commercial supply chain so successfully. Another purpose of this paper was to educate healthcare supply chain professionals that there is no difference of supply chain concepts and applications between healthcare and commercial supply chain. As argued in this paper, the only difference is emphasis and not fundamental concepts. Perhaps the next step should be to test arguments raised in this paper based on empirical data. Several healthcare organizations have been known for their superior use of supply chain tools such as Intermountain Healthcare Systems, ROI (Mercy Health System) and the Mayo Clinic (The 2015 Healthcare Supply Chain Conference, 2015). It is a matter of time that aggressive academic inquiry in this field will be undertaken.

References

Accenture Global Operations: Megatrend Study, 2014. Big data analytics in supply chain: hype or here to stay? www.accenture.com/megatrends

Anderson Group, 2005. Supplier Performance Benchmarking Report (September).

Barnes, S., Mattsson, J., 2016. Understanding current and future issues in collaborative consumption: a four-stage Delphi study. *Technol. Forecast. Soc. Chang.* 104 (March), 200–211.

Benavides, L., Eskinazis, V.D., Swan, D., 2012. 6 steps to successful supply chain collaboration. *Supply Chain Q. Q. 2*, 23.

Boulton, C., 2015. Data analytics are ‘gold’ for pharmaceutical distributor. *IT World* (September 22).

Burns, L.R., 2002. *The Healthcare Value Chain – Producers, Purchasers, and Providers*. A Wiley company, Jossy-Bass.

Butler, P. T., W. Hall, A. M. Hanna, L. Mendonca, B. Auguste, J. Man- yika, A. Sahay, 1997. A revolution in interaction. *McKinsey Q.*, 1, 3–14.

Cecere, L., 2014. Can you Afford the Risk? *Forbes Magazine* (April 16).

Coleman, B.J., Jennings, K.M., 1998. The UPS strike: lessons for just-in-timers. *Prod. Invent. Manag. J. Q. 4*, 63–67.

Craighead, C., Ruamsook, K., 2014. A Supply Chain Talent Perfect Storm? *Supply Chain Management Review*, January/February, pp. 12–17

Council for Supply Chain Professionals, 2015. 2015 Annual Status of Logistics. Council for Supply Chain Management Professionals.

Dacosta-Claro, I., 2002. The performance of material management in health care organizations. *Int. J. Health Plann. Manag.* 17 (1), 69–85.

de Vries, J., Huijisman, R., 2011. Supply chain management in health services: an overview. *Supply Chain Manag. Int. J.* 16 (3), 159–165.

Davenport, T.H., Harris, G.J., 2007. *Competing on Analytics: The New Science of Winning*. Harvard Business School Press, Boston, MA.

Dooner, R., 2014. How supply chain management can help to control health-care cost. *Supply Chain Q. Q. 3*, 50–53.

Duffy, M., 2009. Is Supply Chain the Cure for Rising Health Care Cost? *Supply Chain Management Review*, September, pp. 28–35

Dyer, J., Chu, W., 2003. The role of trustworthiness in reducing transaction costs and improving performance. *Empirical Evidence from the United States, Japan, and Korea*. *Organization Science*, pp. 57–68.

Elmuti, D., Khoury, R., Omran, O., Abou-Zaid, A., 2013. Challenges and opportunities of health care supply chain management in the United States. *Health Mark. Q.* 30 (2), 128–143.

Farrow, S., 2013. Global chief supply chain officer strategy report. A Brief Analysis of eyefortransport's Recent Survey.

Harrington, L., 2015. Solving the talent crisis: Five alternatives every supply chain executive must consider. *Automotive Industry Brief* (www.dhl.com/automotive-talent).

Henke, J., Stallkamp, T., Yeniurt, S., 2014. Lost supplier trust and lost profit: how Chrysler missed out on \$24 billion in profit over the past 12 years? *Supply Chain Management Review* 18 (3), 24–32.

IBM Center for Applied Insights, 2012. Outperforming in Data-rich, Hyper-connected World. IBM Institute of Business Value.

John, G., 2014. At Long Last, Proof that Supplier Relationship Pays off. *SCM World*, August.

Johnson, B., 2015. Intermountain healthcare supply chain. The 2015 Healthcare Supply Chain Conference, New Orleans, LA, February 21–25.

Kavilanz, P., 2009. Health cares' six money-wasting problems. *CNNMoney.com* (August 10).

Korean Herald, 2007. Government Introduces Standardized Audit Process. August 22.

Kumar, N., 2004. Two tough companies learned to dance together. Marketing as strategy: understanding the CEO's agenda for driving growth and innovation. Harvard Business School Press, Boston, MA, pp. 121–123.

Kwon, I.-W., Hong, S.-J., 2011. Health care supply chain management in the United States: new paradigm for roles of distributors. *Int. J. Health Manag. Inf.* 7, 73–82.

Kwon, I.-w., Hamilton, J., Hong, S.-j., 2011. Trust and transaction cost in supply chain cost optimization: an exploratory study. A Chapter in *Inter-organizational Information Systems and Business Management: Theories for Researchers by IGI Global Publisher*, pp. 107–119.

Kwon, I.-W., Suh, T.W., 2004a. Factors affecting the level of trust and commitment in supply chain management. *J. Supply Chain Manag.* 40 (2), 4–14.

Kwon, I.-W., Suh, T.W., 2004b. Trust, commitment and relationships in supply chain management – path analysis. *Supply Chain Manag. An Int. J.* 10 (1), 26–32.

Lacy, R.G., 2001. *The Value of eCommerce in the Healthcare Supply Chain: Industry Study Report*. Technical Report. Anderson, New York.

Lin, C.-T., Wu, W.-J., Cheng, L.-M., 2015. Toward understanding integration of heavyweight-product managers and collaboration software in collaborative product development: an empirical study in Taiwan. *Technol. Forecast. Soc. Chang.* 99 (October), 156–167.

Marino, A., Edwards, D.J., 1999. Give logistic its own place in the price equation. *Hosp. Mater. Manag.* 24 (3), 10–11.

Nachtmann, H., Pohl, E., 2009. *The State of Healthcare Logistics; Costs and Quality Improvement Opportunities*. Center for Innovation in Health Logistics. University of Arkansas, AR.

New Intelligence Enterprise, 2011. A Joint Research Project between Sloan Management Review and IBM Institute. Business Value Research Partnership, MIT.

North, D., 1990. *Institutions, Institutional Change and Economic Performance*. Cambridge University Press, Cambridge, U.K.

Oliveira, M.D., Pinto, C.G., 2005. Health care reform in Portugal: an evaluation of the NHS experience. *Health Econ.* 14 (9), 203–220.

O'Brien, J., 2014. *Supplier Relationship Management; Unlocking the Hidden Value in your Supply*. Kogan Page, Base.

O'Marah, K., 2015. Beyond supply chain. *SC World* (September 1).

Poirier, C.C., Quinn, F.J., Swink, M.L., 2010. *Diagnosing Greatness*. Ross publication, pp. 101–103.

PRTM, 2010. *The Performance Measurement Group*.

Pricewaterhouse Cooper, 2008. *Health Research Institute*.

Reeve, J., 2002. The Financial Advantages of the Lean Supply Chain. *Supply Chain Management Review*, pp. 42–49 (January/February).

Robinson, C., Malhorta, M., 2005. Defining the concept of supply chain quality management and its relevance to academic and industrial practice. *Int. J. Prod. Econ.* 96 (3), 315–337.

Rottman, J.W., Lacity, M.C., 2006. Proven Practices for effectively Offshoring IT Work. *MIT Sloan Management Review*, Spring, pp. 56–63.

Ryder Supply Chain Solution, 2011. www.ryderscs.com.

Saddle Creek Corporation, 2009. *Cross-docking Trend Report*.

Sander, J., 2015. Supplier Advisory Council Enables Better Buyer/Seller Relationship. *Supply chain Management Review*, pp. 20–27 (March/April).

Schneckenberg, D., Truong, Y., Mazloomi, H., 2015. Microfoundations of innovative capabilities: the leverage of collaborative technologies on organizational learning and knowledge management in a multinational corporation. *Technol. Forecast. Soc. Chang.* 100 (November), 358–368.

Schneller, E.S., Smeltzer, L., 2006. *Strategic Management of the Health Care Supply Chain*. Jossy-Bass.

Seifert, D., 2003. *Collaborative Planning, Forecasting, and Replenishment; how to Create a Supply Chain Advantage*. Amacom Publishers.

Spiegel, R., 2011. SRM Leaders Outpace Peers on Lead Time, Other Key Metrics. *Supply Chain Management Review*, January/February, pp. 47–49.

- Top 10 Healthcare Supply Chain Organizations, 2015. *The 2015 Healthcare Supply Chain Conference, New Orleans, LA, February 21–25*.
- Trent, R., Zachria, Z., 2012. The Wisdom of Becoming a Preferred Customer. *Supply Chain Management Review*, pp. 10–18 November.
- Vitasek, K., Mantodt, K.B., Abbott, J., 2005. What Makes a Lean Supply Chain. *Supply Chain Management Review*, pp. 39–45 September/October.
- Voluntary Interindustry Commerce Standards–VICS, 2013. www.vics.org.
- Watson, M., 2014. Three things you should know about big data and analytics. *Supply Chain Quarterly Q. 3*, 44–48.

Ik-Whan G. Kwon is a professor of Decision Sciences and ITM at Saint Louis University and is currently serving as director of Center for Supply Chain Management Studies at Saint Louis University. He is member of editorial board, at *International Journal of Business Innovation and Research*, *International Journal of Information Systems and Supply Chain Management*, and *International Journal of Procurement Management*. His current research interests include Supply Chain Design, Strategy and Implementation, and Lean Six Sigma in Supply Chain and Logistics. He is the author of “Comparative Efficiencies of Specialty Coffee Retailers from the Perspectives of Socially Responsible Global Sourcing,” published at *The International Journal of Logistics Management*, and “Examining the Roles of Suppliers in Large Scale System Integration Using a Coordination Theory: An Exploratory Study,” at *The International Journal of Procurement Management*.

Sung-Ho Kim is doing research at St. Louis University as a visiting professor. He earned his Ph. D at Yonsei University and his recent publications include “The Study of Healthcare Supply Chain Management in United State for Justifying Strategical Implementation,” published at *Korea Journal of Hospital Management* and “The Organizational Citizenship Behavior and Organizational Effectiveness of Hospital Employees” at *Korean Journal of Health Policy and Administration*.

David G. Martin is a professor of finance and currently the dean of the Ancell School of Business at Western Connecticut State University. He earned a B.A. in history from Long Island University, an MBA from Western Illinois University, and a Ph.D. in business administration from Saint Louis University with a major in finance.