Case study

Collaborative management of inventory in Australian hospital supply chains: practices and issues

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Abstract

Purpose – The purpose of this paper is to develop an understanding of the nature of collaborative arrangements that partners in Australian hospital supply chains use to manage inventories.

Design/methodology/approach – A case study involving a supply chain network of ten healthcare organisations (three pharmaceutical manufacturers, two wholesalers/distributors and five public hospitals) was studied. Data included 40 semi-structured interviews, site visits and examination of documents.

Findings – This study highlights the existence of a variety of collaborative arrangements amongst supply chain partners such as the "Ward Box" system (a variant of the vender managed inventory system) between wholesalers/distributors and hospitals. The materials management departments were more willing than their pharmacy counterparts to participate in a variety of partial and complete outsourcing arrangements with wholesalers/distributors and other hospitals. Several contingent factors were identified that influenced development of collaborative arrangements.

Research limitations/implications – This study is limited to the Australian healthcare sector. To improve generalisability, this study could be replicated in other industry sectors and countries.

Practical implications – Application of collaborative arrangements between manufacturers and wholesalers/distributors would improve inventory management practices across the supply chains. Also, learning from materials management departments could be transferable to pharmacy departments.

Originality/value – Several contingent variables for the implementation of collaborative inventory management arrangements between healthcare supply chain partners have been identified. Methodologically, data across three echelons in the supply chains (manufacturers, wholesalers/distributors and hospitals) were collected and analysed.

Keywords Supply chain management, Health care, Distribution and inventory management, Australia

Paper type Case study

Introduction

Healthcare costs in Australia and many other countries are growing rapidly. Since supply-related costs constitute approximately 30 per cent of a hospital's expenditure (Burns, 2002; Dacosta-Claro, 2002; Scheller and Smeltzer, 2006), reducing this would assist in managing the overall costs to the sector. Research shows that a significant portion of these costs can be reduced by implementing effective supply chain practices (Haavik, 2000; Poulin, 2003; de Vries, 2011). However, unlike other sectors such as discrete parts manufacturing and fast-moving consumer goods where there has been a long history and experience with management of inventory, the healthcare sector is behind other industry sectors in implementing effective supply chain management (SCM) practices (McKone-Sweet *et al.*, 2005; Baltacioglu *et al.*, 2007).

The main reason for the sector's difficulties in implementing effective SCM practices is that the healthcare supply chains are much more complex compared to supply chains in other industries (Shah, 2004; Scheller and Smeltzer, 2006). Several factors contribute to this complexity. The first is that physicians are the key decision-makers regarding the procurement of prescription medicines, but they generally

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have a limited understanding of operations management and SCM techniques and practices (Scheller and Smeltzer, 2006). Second, the pharmaceutical industry is influenced by strong institutional and regulatory pressures, such as the number of mainstay drugs that are ending their patent protection tenure, thereby fuelling the growing competition from generic drugs (Shah, 2004). The regulatory regime of the pharmaceutical industry causes problems in determining accurate sales forecasts. This is essentially because it is difficult to gauge the magnitude of the competition from generics entering the marketplace (Kiely, 2004; Shah, 2004). Third, pharmaceutical products are characterised by long developmental cycles that are distinctly different from medical devices. These long lead times have a significant impact on capacity planning and supply chain strategies, particularly inventory management (Shah, 2004). The final challenge with inventory management within the healthcare supply chains is that hospitals are operationally different from the other businesses because it is extremely difficult for them to predict their patient mix and ultimately their supply consumption (Jarrett, 1998; Scheller and Smeltzer, 2006). This is specifically the case in emergency interventions, as it is difficult to ascertain the "type" of patient that will come to the hospital. This has major ramifications, particularly for pharmacy departments in hospitals that carry high levels of safety stock to hedge against uncertainties such as daily demand fluctuations and supply bottlenecks. The net result is that hospital pharmacies have to maintain excess stock to insulate them against emergencies and an unpredictable demand (Beier, 1995; Danas *et al.*, 2006). These factors lead to perennial problems such as stock-outs and drug expiry within pharmacy departments in hospitals.

In this study, we are interested in better understanding the inventory management related practices of hospital supply chains with the view that this heightened understanding can assist in overcoming some of the challenges outlined above. We have considered both pharmaceutical products as well as medical consumables such as gloves and syringes in our study. We attempt to answer the following two questions:

1 How do different actors in the hospital supply chain collaboratively manage inventory?
2 What contingent factors influence the development of collaborative inventory management practices?

The Australian hospital supply chain has a three-tiered structure including the manufacturer, wholesaler/distributor and a hospital. This implies that the flow of products from the manufacturer to the hospital typically takes place through the wholesaler/distributor. Therefore we employed a case study design involving a network of ten organisations from the healthcare sector including each of these three tiers to answer the above two research questions empirically. By answering these research questions we contribute to the literature by developing a list of contingent factors and associated propositions that can guide inventory management decisions in healthcare organisations.

Literature review

Management of inventory in the healthcare sector

There have been several suggestions in the literature to deal with inventory management problems in the healthcare sector, particularly within the pharmaceutical domain. For example, Danas *et al.* (2002) suggest forming a virtual hospital pharmacy. Under the virtual pharmacy arrangement, the pharmacy department within a hospital will have access to information on the different pharmaceutical stock-keeping units stored in the clinics of hospitals in the same geographical area so that they can be shipped out when required. This proposed conceptual solution would be a good solution to critical problems such as stock outs, minimise the amount of stock carried by individual hospitals and provide more time for clinicians to focus on patient care rather than administrative functions. Further, studies highlight that using techniques such as inventory pooling and transhipment within such arrangements may lead to reduction in inventory but may have implications on customer service levels and associated transportation costs (Bendoly, 2004; Tagaras, 1999).

In a subsequent study, Danas *et al.* (2006) suggest developing a classification framework for drugs on a scale of A to D, with A implying that the drug is "very important" and D implying that the drug is "not important". This importance scale is based on four factors:

1 patient treatment criticality;
2 supply characteristics;
3 inventory problems; and
4 usage rates.

Based on this scheme, the authors recommend that pharmacy departments maintain adequate stock for Class A drugs and spread out the stock for Class B drugs across the other hospitals in the network. Class C drugs should be stored in a ward or a clinic, allowing any excess stock to be located through the virtual pharmacy system. Under this system, the hospitals would not carry any safety stock for the least important Class D drugs. Although this concept of stockless inventory can be accomplished by deploying an intranet/extranet infrastructure or using an electronic data interchange (EDI) system, its practical efficacy remains unproven.

Other scholars such as Nicholson *et al.* (2004) use simulation modelling and propose that outsourcing of non-critical medical supplies (for example latex gloves and plastic/disposable sheets) trims inventory costs and does not compromise on the quality of care, which is critical in the healthcare sector. However, the problem with these models is that they are based on strong underlying assumptions. As highlighted by de Vries (2011), inventory management decisions in hospitals are influenced by myriad stakeholders, such as the pharmacy department, distribution, senior management and clinical staff. Further, several contingent factors are also at play, including issues such as top management support, project management issues and the setting of the health delivery. These factors can be difficult to include adequately in simulation models.

In terms of strategic partnerships between hospitals and their supply chain partners, Scheller and Smeltzer (2006) highlight the role of the distributor and the hospital within the distribution function, which is shown in Table I. It is evident from Table I that from level 1 onwards partial outsourcing of the distribution function commences. A decision to outsource the distribution function allows the hospital to allocate capital to other critical functions. This decreases the workload of the senior clinical staff, who can then focus on other strategic activities in the hospital rather than supervising supply chain personnel in the hospital. However, concerns have been raised

Table I Levels of the distribution function

Level	Distributor function	Hospital function
00	Supplier-held and -managed products through supplier distribution agents	Hospital frequently does not take ownership of such goods or goods enter into hospital accounting and inventory system after they have been used
0	Supplier-held and -managed products through third-party logistics companies to reduce transportation costs and management and to better connect to suppliers and distributors	Hospitals act as a receiver for the product and deploy the product into use or delivery
1	Distributor brings ordered goods to hospital warehouse	Hospital employees break down orders into quantities that are transported by hospital employees to individual hospitals in a system and onto floors for storage
2	Distributor breaks down orders into quantities needed on different floors and brings ordered goods to hospital shipping dock	Hospital employees transport goods to floors and stock goods into floor stockrooms and dispensing systems
3	Distributor carries out level 1 and 2 functions and transports goods to the floor	Hospital employees place goods into floor stockrooms and dispensing systems
4	Distributor carries out levels 1, 2 and 3 tasks and places goods into floor stockrooms and dispensing systems	Hospital employees have minimal role in transporting goods and servicing dispensing systems

Source: Scheller and Smeltzer (2006, p. 30)

if the hospital is operating the distribution function at level 4. These concerns are particularly relevant in a rural setting where there can be a considerable distance between the hospital's central store and the distributor. In addition, this method has resulted in inventory cost reduction but inventory management costs have remained largely unchanged (Rivard-Royer *et al.*, 2002).

Whitson (1997) argues that the materials management and the pharmacy departments in a hospital would be ideal candidates for using a just-in-time (JIT) system because they have "manufacturing like" operations as they deal with high volume products, tangible items and operations that are repetitive. However, he did not make any explicit distinctions between JIT techniques to be more applicable to scheduled interventions *vis-à-vis* emergency admissions. Further, questions have been raised about the suitability of the JIT technique in a rural setting where the warehouse can be at a considerable distance from the distributor. Stock-outs of critical supplies could have catastrophic consequences in a hospital environment (Jarrett, 1998).

To cope with the challenges of having a "stockless system", a hybrid stockless method was implemented in a Canadian hospital (Rivard-Royer *et al.*, 2002). The method was called "hybrid stockless" because it combined a stockless method with a conventional approach to goods distributed through a hospital's central store. Under the hybrid stockless system, the distributor supplied high-volume products directly to the point of each patient care unit (e.g. ward or theatre), whereas low-volume products were delivered through the hospital's central store. The central store was then responsible for breaking down these products into point-of-use quantities and supply to each patient care unit (Rivard-Royer *et al.*, 2002). This pilot project in Canada reported mixed results, as it led to cost reduction for the hospitals by improving inventory management and efficiency amongst the nursing staff, but increased the workload of the distributors.

Application of vendor managed inventory system in healthcare supply chains

Strategic approaches to the management of inventory in the literature highlight the significance of the vendor managed inventory (VMI) system. The VMI strategy originated in the USA in the 1980s and early adopters of this strategy were large retailers such as Wal-Mart and JC Penney. VMI is a system whereby the supplier takes responsibility for monitoring the retailer's inventory levels and makes periodic replenishment decisions regarding order quantities, delivery mode and timing of replenishments (Waller *et al.*, 1999; Sahin and Robinson, 2002; Simchi-Levi *et al.*, 2008). The two essential elements for the success of a VMI arrangement are first, high levels of trust between supply chain partners participating in such an arrangement, and second, the ability of the supplier to use data for planning purposes and aligning incentives and organisational structures appropriately to such an arrangement (Waller *et al.*, 1999; Disney and Towill, 2003; Claassen *et al.*, 2008). Further, Claassen *et al.* (2008) testify empirically that implementation of the VMI system leads to improved service levels rather than cost reductions.

Most of the empirical studies addressing the issue of VMI have focussed on manufacturing firms and retailers (Waller *et al.*, 1999; Achabal *et al.*, 2000; Vigtil, 2007; Kauremaa *et al.*, 2009). The literature has largely ignored the application of the VMI system within the healthcare domain. However, some recent studies highlight the advantages of implementing the VMI system in the healthcare setting. Kim (2005) discusses the adoption of the VMI system between the wholesaler and the hospital warehouse specifically for pharmaceutical products in South Korea. This had several advantages, with the most significant being the reduction in inventory levels by 30 per cent. Further, it decreased the workload of the pharmacy staff in the hospital and facilitated information integration between the wholesaler and the hospital as the wholesaler had access to information on the usage of drugs in the hospital.

The application of the VMI system studied by Kim (2005) seems rather simplistic when compared to the study conducted by Danese (2006). This is because the study by Danese (2006) fills a void in the literature by discussing the applicability of this system at the "network level", compared to previous studies that have evaluated the application of this strategy at the dyadic level. This was accomplished by exchanging information vertically with supply chain partners

positioned upstream and downstream in the network while the horizontal information flows were between the supply chain partners in the same echelon in the supply network. This study highlights that the use of IT is mandatory if the VMI system is implemented across the network. This is contrary to studies that suggest that IT is an enabler but not critical for a successful VMI arrangement (Waller *et al.*, 1999; Vigtil, 2007). The other salient issues addressed by this study are that sharing of information across the network enables each participating organisation to appreciate the performance measures set by other members and enable building of trust in the long run.

Although the study by Danese (2006) was a single case study conducted within a large pharmaceutical manufacturer (GlaxoSmithKline) as the focal organisation in the network, it opened up a platform for discussing different forms of collaborative arrangements amongst network members. For example, would a study conducted downstream with the hospital as the focal organisation in the chain raise similar issues?

A recent study investigating the application of collaborative practices with supply chain partners conducted in the Malaysian context recommends adopting a VMI solution between the wholesaler and clinic within a two echelon supply chain (Mustaffa and Potter, 2009). This study also suggests that application of the VMI system leads to higher customer service levels (i.e. delivering the right quantity of the product to the clinic) and improvements in key supply chain variables such as decreasing stock-outs and eliminating the bullwhip effect.

The above review of the literature on the management of inventory in healthcare and hospital settings where a supply chain management perspective is taken shows that the literature is underdeveloped. There is not much guidance from literature as to what exactly are organisations in the sector doing with respect to applying emerging supply chain management concepts, techniques and technologies to managing inventories. Hence, we propose an exploratory study that would inductively uncover the practices of healthcare supply chains so that some initial understanding of these practices can be developed.

Research method

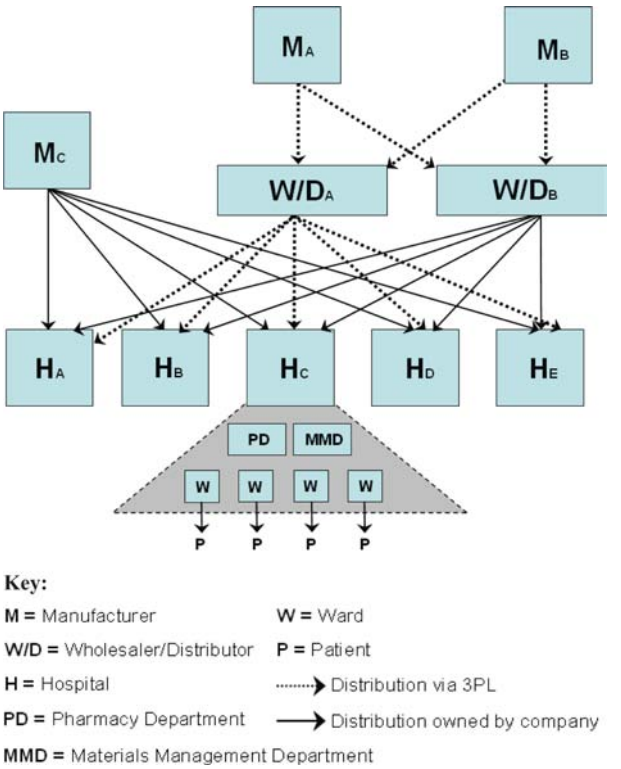
Healthcare expenditure in Australia is $AU103bn, accounting for 9 per cent of GDP, of which 14 per cent is spent on drugs (Australian Institute of Health and Welfare, 2010). Australia has a mix of public and private funded healthcare system. The public sector accounts for 69 per cent of the total funding provided jointly by federal and state governments. The balance of 31 per cent is funded by the private sector (Australian Institute of Health and Welfare, 2010).

Supply chain structure of organisations participating in this study

The supply network structure of the organisations participating in this study is shown in simplified form in Figure 1. Figure 1 illustrates the different organisations in the supply network, shows their inter-relationship and maps out the scope of the supply chain.

The pharmaceutical manufacturers (M_A, M_B and M_C) represent the first echelon in the supply chain. Figure 1 further highlights that M_A and M_B distribute pharmaceutical products to the wholesalers/distributors through a third-party

Figure 1 Supply chain structure of the organisations participating in the study



logistics provider (3PL), whereas M_C distributes the goods directly to the hospitals. The second echelon in the chain was the wholesaler/distributors, represented as W/D_A and W/D_B in Figure 1. The supply chain terminates when the products reach the wards (designated "W" in Figure 1) within the five public Hospitals (H_A-H_E). W/D_A employed a 3PL to distribute the goods to the hospitals, whereas W/D_B conducted the distribution activity independently.

The cases for this study were selected so that there were similarities amongst cases for theoretical replication purposes (Yin, 2003) along with differences and diversity in the cases in order to maximise learning (Stake, 1995; Stuart *et al.*, 2002). Further, case study scholars recommend including extreme or "polar cases" in the sample to check whether the emergent theory is applicable under those circumstances (Eisenhardt, 1989; Yin, 2003; Eisenhardt and Graebner, 2007). This was particularly evident with hospitals which were the focal entity in the network as hospitals H_A, H_B and H_C were similar in terms of their size, number of SKUs they handled and their budgets. They also represented the largest hospitals within a network of hospitals across the metropolitan district. Hospitals H_D and H_E represented the extreme or the polar cases as Hospital H_D was a specialist hospital treating patients with eye and ear ailments, whereas Hospital H_E was a regional hospital. The pharmaceutical manufacturers were large multinational corporations manufacturing branded drugs but differed in the types of drugs they manufactured. Manufacturer M_C had a different supply chain structure (see Figure 1 and Table II for details).

Although Australia has a mix of public and private hospitals, this study specifically focuses on public hospitals.

Table II Study participants

Organisation type	Headquarters	Employees (worldwide)	Number of stock keeping units	Products	Annual turnover (worldwide)	Supply chain systems	Interviewees	Data sources
Manufacturer A	Australia	1,600	1,200	Oncology	$A687m	ERP system (SAP)	Supply Chain Manager, Operations Manager ($n = 2$)	Interviews, plant tours, website material
Manufacturer B	USA	44,000	500	Cardio-vascular, neuroscience, oncology	$US20.9bn	ERP system (Manugistics)	Supply Chain Manager, Corporate Affairs Senior Manager, IT Manager ($n = 3$)	Interviews, plant tours, website material, company annual report
Manufacturer C	USA	47,000	9,000	Intravenous solutions, IV fluids	$US9.8bn	ERP system (JD Edwards)	IT manager, Strategy Manager, Operations Manager ($n = 3$)	Interviews, plant tours, website material, company annual strategy documents
Wholesaler/ distributor A	Australia	6,000	17,000	Pharmacy and non-pharmacy products	$A3.4bn	PC.Net	Customer Relationship Manager, Operations Manager ($n = 2$)	Interviews, website material
Wholesaler/ distributor B	Australia	300	17,000	Equipment, medical and pharmacy products	$A1.3bn	SOS	Operations Managerm CIO, Sales Manager ($n = 3$)	Interviews, website material, internal IT strategy documents
Hospital A	Australia	10,000	3,000	Pharmacy products	$A38m	Merlin	Director Pharmacy, Deputy Director Pharmacy, Purchasing Manager, Ward Staff ($n = 4$)	Interviews, website material, hospital annual report, examination of "existing" processes
Hospital B	Australia	7,500	4,500	Pharmacy products	$A30m	Merlin	Director Pharmacy, Deputy Director Pharmacy, Director Materials Management ($n = 4$)	Interviews, website material, hospital annual report, examination of "existing" processes
Hospital C	Australia	4,200	3,000	Pharmacy products	$A12m	ISOP	Director Pharmacy, Inventory Manager, Purchasing Manager, Purchasing Officer, Director Materials Management ($n = 4$)	Interviews, website material, hospital annual report, examination of "existing" processes
Hospital D	Australia	744	1,300	Pharmacy products	$A1.9m	Merlin	Director Pharmacy, IT Manager, Purchasing Manager, Director Materials Management ($n = 4$)	Interviews, website material, hospital annual report, examination of "existing" processes
Hospital E	Australia	1,020	2,500	Pharmacy products	$A3.9m	Stocker	Director Pharmacy, Director Materials Management ($n = 2$)	Interviews, website material, hospital annual report, examination of "existing" processes

Several reasons were responsible for confining this study to public hospitals amongst which the most noteworthy were:

- 41 per cent of the healthcare expenditure by the Australian government is on public hospitals (Australian Institute of Health and Welfare, 2008); and
- expenditure on hospitals contributed the largest proportion of real growth in health expenditure amounting to 34 per cent.

Out of this growth in expenditure, public hospitals were responsible for an increase in the healthcare expenses of 24 per cent and finally public hospitals account for 61 per cent of all patient admissions in the country (Australian Government: Department of Health and Ageing, 2007). The public hospitals in this study are confined to the state of Victoria. These hospitals have two different departments that handle procurement: pharmacy department (PD) and Materials Management Department (MMD). Pharmacy departments usually carry pharmaceutical products, drugs, intravenous fluids, etc., whereas the MMD handle medical consumables, furniture, stationary, etc. Both these departments were included in this study.

The end patient has not been included within the scope of this study. This is because the focus of this study is not the in-patient in the hospital. It is also important to clarify that the patient in the pharmaceutical hospital supply chain is not the end user in the traditional sense, particularly for pharmaceutical products, because the medical staff and physicians are responsible for prescribing the necessary medication (Scheller and Smeltzer, 2006). Scholars further suggest that it is useful to have a focal firm when the entire network is being analysed (Lamming *et al.*, 2000). The "focal" entity in the chain is the hospital. The hospital's suppliers (i.e. manufacturers and wholesalers/distributors) are a critical part of this study.

Data collection and analysis procedure

Data was collected from all ten organisations in this network. Several researchers have suggested employing a case study design when the study seeks to investigate the entire supply chain or multiple echelons in the chain (McKone-Sweet *et al.*, 2005; Harland and Caldwell, 2007; Mustaffa and Potter, 2009).

The study involved multiple sources of data, such as 40 semi-structured interviews, analyses of organisations' annual reports, plant tours, and use of website materials and examination of process maps. Details of the interview protocol are provided in the Appendix. The interviews conducted were transcribed and loaded into N-Vivo software for analysis. N-Vivo is a qualitative text analysis tool that is used for storing the transcripts, coding and analysis (Durian, 2002). Since the data was collected at the organisation level, the unit of analysis was the organisation. The case study analysis, however, was conducted at two levels. The first was at the organisational level by conducting a within- and cross-case analysis of organisations embedded within an echelon in the supply chain. For example, a cross-case analysis was conducted across the three cases within the manufacturer category. The second was across the three different echelons within the supply chain (manufacturers, wholesaler/distributor and hospital).

This study did not find significant differences "within the cases" other than the public hospitals. Since the data within public hospitals was collected from pharmacy and materials management departments, there were considerable differences between these departments.

The data was analysed inductively without a prior theory in consideration. In order to maintain rigor in the research procedures and ensure reliability and validity of results, several procedures were adopted as recommended in the literature (Anfara *et al.*, 2002; Stuart *et al.*, 2002; Yin, 2003). These included maintaining a case study database, triangulation of data sources, interviewing personnel with similar designations in organisations, and finally, draft case study reports were reviewed by key interviewees.

Findings

The results of this study revealed a plethora of variations in the application of the VMI system and other collaborative arrangements by supply chain partners within the healthcare domain, specifically within the pharmacy and MMD in the hospitals. We present the results categorised for each stakeholder group.

Manufacturer perspective

Pharmaceutical manufacturers A and B reported an absence of collaborative arrangements with their supply chain partners downstream in the supply chain. Manufacturer M_C was the only exception and had implemented the VMI system with hospitals H_A and H_C.

The rationale for the implementation of the VMI system was that manufacturer M_C had a distinct supply chain structure as it supplied directly to hospitals and did not use a wholesaler/distributor. In addition, the "product type" that this manufacturer dealt with was intravenous fluids which could be classified under the functional product category. Intravenous fluids along with medical consumables such as gloves and syringes within the healthcare context have characteristics such as a relatively stable demand, long product life cycle and a low stock-out rate (Fisher, 1997). Finally, a key prerequisite for the application of this system was that the manufacturer had a storeroom in the hospital and its own staff performed the crucial internal distribution and inventory management functions. The system was adapted to the requirements of each individual hospital. In some cases, the manufacturer delivered directly to the pharmacy department. In other cases, the manufacturer split the order and delivered to the individual wards to meet their specific needs.

Wholesaler/distributor perspective

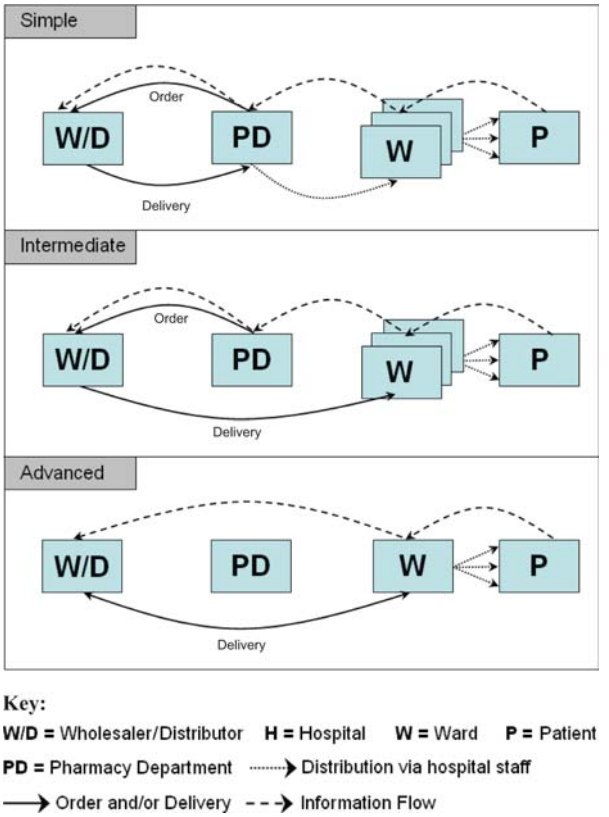
Amongst the two wholesalers/distributors, Wholesaler/Distributor W/D_B was relatively more progressive in implementing the VMI system and referred to it as the "ward box" system with the successful application of this system across hospitals H_A, H_B, H_C and H_D for products ranging from pharmaceuticals to medical/surgical devices. Under this system, the hospital placed direct orders with the wholesaler/distributor for the items required for a specific ward/theatre and the wholesaler/distributor replenished the wards accordingly.

This model had three variants:

1 simple;
2 intermediate; and
3 advanced.

These models are shown in diagrammatic form in Figure 2.

Figure 2 Three variants of the "ward box" system



Under the simplified version, the hospital staff used bar coding technology to determine the order quantities and subsequently placed the order on the wholesaler/distributor's online system. Since the "ward box" system was used for specific wards/theatres (e.g. neurology, oncology, etc.), the order quantities were determined based on past forecasts and were modified based on the patient numbers. The goods were delivered to a designated area within the hospital and final distribution to the wards was the responsibility of the hospital. This version was closest to the conventional distribution system with the only exception being the use of technology for determining order quantities and sending purchase order requisitions electronically. Under the intermediate system, the ordering was conducted in a similar fashion as outlined in the simple version. However, the wholesaler/distributor picked and packed the goods and delivered directly to the individual theatre/ward in the hospital. A prerequisite for this process to function was compatibility in the information systems between the hospital and the wholesaler/distributor. Finally, under the advanced version, the wholesaler/distributor provided a comprehensive inventory management solution monitoring stock levels of each ward/theatre using appropriate barcode technology. The goods were delivered directly to the wards/theatre and unpacked by the staff of wholesaler/distributor (see Figure 2 for details). Setting up the advanced form of the "ward box" system required detailed analysis as the wholesalers/distributors had to assess the needs of the wards and ascertain if they were able to deliver all the product lines as required. The final distribution from the wards to each patient bed was the responsibility of the hospital staff in all the three variants of the "ward box" system.

The advanced variant of the "ward box" system reported the most benefits both to the hospital staff and the wholesalers/distributors. The wholesalers/distributors were able to determine an accurate account of the consumption levels in the hospital, thereby reducing the inventory holding costs. The purchasing staff in PD and MMD had fewer purchase orders to handle and the clinical staff could focus on their core functions. It is important to clarify that based on the literature; the advanced version of the "ward box" system better represented a true application of a VMI arrangement.

Hospital (pharmacy and MMD) perspective

A within case analysis of the public hospitals identified a series of challenges that pharmacy departments encountered on the path towards developing collaborative arrangements with supply chain partners for the purposes of inventory management, particularly the pharmaceutical manufacturers. The MMDs, on the other hand, were more receptive to the idea of engaging in collaborative relationships with supply chain partners.

Pharmacy departments faced a number of specific issues when contemplating developing collaborative arrangements with supply chain partners. These are as follows:

- *Trust issues*. There was limited trust between the hospitals and the manufacturers, which was the greatest stumbling block in entering into any form of collaborative arrangement. The literature identifies trust as the most crucial ingredient for a successful VMI arrangement (Augulo *et al.*, 2004). The reason for the lack of trust was because prescription of pharmaceutical products is a distributed decision making process. Physicians in the hospitals are responsible for prescribing the medication to the end patients. As such, physicians are actually the "surrogate consumers" for the drugs (Aggarwal *et al.*, 1998). Further, once a physician develops preferences for a specific brand, it is hard to make them switch to alternative products (Scheller and Smeltzer, 2006; Jaakkola and Renko, 2007). Therefore the marketing representatives of the pharmaceutical manufacturers have a vested interest in establishing close relationships with the physicians in the hospitals (Scheller and Smeltzer, 2006). But, from the hospital's perspective, disclosure of information on drug usage variables would violate patient privacy, which is a significant priority for the hospital. Moreover, the fact that public hospitals are not-for-profit organisations whereas pharmaceutical manufacturers are large multinational corporations with the key motive to increase market share and improve profitability culminated in the lack of information sharing and distrust between these entities. The task of managing the inventory of pharmaceutical products was particularly challenging in hospitals because the physicians did not keep the pharmacy departments informed when they ceased to prescribe a particular drug for a specific ailment. There was weak information flow between the physicians and the pharmacy departments.
- *Divergent goals*. There was strong degree of goal incongruence between the pharmaceutical manufacturers and the pharmacy departments in the hospitals. This was essentially because the pharmaceutical manufacturers were driven by profit maximisation and the hospitals

were weary of the fact that a collaborative arrangement would lead to an increased dependence on this entity. This would create a fertile scenario for opportunistic behaviour and development of monopoly entities in the market. The other factor that contributed to the debate on goal incongruity was that pharmacy departments were specifically concerned with the issue of patient safety and therefore were not comfortable with relinquishing control over the inventory management function and handing it over to the wholesalers/distributors. Pharmacy departments further indicated that before embarking on a VMI initiative, they would need to ensure that vendors had adequate stock of the items as stock-outs of crucial drugs could lead to disastrous consequences.

- *Cultural inertia*. The directors of the pharmacy departments in hospitals H_A, H_B, H_C and H_E were rather sceptical of collaborative relationships with supply chain partners. This scepticism stemmed from the fact that they would lose control over their crucial clinical functions such as checking the latest drug on the market, seeking cheaper alternatives and making necessary recommendations. Further, the pharmacy personnel believed that with the application of this system, they would miss key signals such as why the usage of a particular medication was changing. These indicated that the hospital pharmacists had an inherent fear of their roles becoming redundant.
- *Physical and technical infrastructure*. Concerns were raised regarding the physical and technical infrastructure required at the hospitals, wholesalers/distributors and the manufacturers to make such initiatives viable. Interviewees based in the metropolitan region added that hospitals were constrained by the availability of physical infrastructure, particularly the space required for storing products for implementing such an initiative. This was evident in the case of manufacturer M_C, which had very restricted application of the VMI principle with hospitals H_A and H_C because M_C supplied intravenous fluids that were heavy and bulky items and therefore required sufficient storage capacity at the hospital. In regards to technical infrastructure, research into the application of the collaborative arrangements such as VMI have highlighted the importance of information technology and the significance of publishing performance measures of supply chain partners in the network as a prequel to information sharing (Danese, 2006; Vigtil, 2007). Most hospital pharmacists expressed scepticism that such systems could be implemented inexpensively and without glitches.
- *Size of the hospitals*. For such an initiative to be financially viable, the size of the hospitals was a crucial variable. For example, out of the 762 public hospitals in Australia, only 45 have been classified as "large"; these are located in metropolitan areas and have an average bed size of 142. The average bed size for an Australian public hospital is 46 (Australian Government: Department of Health and Ageing, 2009). On the other hand the average bed size for a hospital in the USA is 164 (American Hospital Association, 2009). An obvious impact of having hospitals with a large bed capacity is that the wards and theatres need to be larger. Therefore, due to the obvious financial savings, hospitals in the USA have been more receptive to the application of the VMI system.

As for the MMDs, within-case analyses conducted across the five hospitals highlighted that the MMDs were more receptive to implementing the VMI system and other collaborative relationships with supply chain partners. Further, cross case analyses revealed a plethora of variations on how the collaborative arrangements for handling of inventory were implemented across MMDs in different hospitals. The discussion that follows provides insights into the application of this system. The associated learnings are transferable to pharmacy departments.

At the outset, material managers mentioned that supplies of products such as laundry, cleaning equipment and stationary were completely outsourced to third party providers. Studies show that hospitals frequently outsource their information systems, linen or warehousing services (Scheller and Smeltzer, 2006; Pan and Pokharel, 2007). Further, the VMI system had been adopted for products such as sutures, stents and prosthetics. Under this arrangement, the inventory was owned by the hospitals but managed by the vendors on variables such as determining the stock level, recommended ordering and restocking process. The VMI system functioned very effectively for these items because of the inherent complexities embedded in these items such as they were required in a variety of sizes/dimensions, were of a high dollar value, had low turnover rates and their usage was a function of the patient mix.

This study also uncovered a unique collaborative relationship that existed between the MMD at hospital H_D and wholesaler/distributor W/D_A. Under this arrangement, the MMD had outsourced the functioning of its department to the wholesaler/distributor. The mechanics of this arrangement were that the negotiation process with the suppliers and pricing contracts was the hospital's responsibility. However, the invoicing and ordering was conducted by the wholesaler/distributor. The MMD paid a contract fee for this service. The wholesaler/distributor managed the warehouse, purchased, stocked, picked and packed the goods and delivered them to the specific hospital site. The wholesaler/distributor also had necessary personnel on site that distributed the goods within the hospital thereby making it a fully managed supply service. But this collaborative arrangement could be labelled as partial outsourcing as it was the hospital's responsibility to negotiate the price and the terms of the contract with the manufacturers and suppliers. Compatibility of information systems between the wholesaler/distributor and MMD and trust between both the parties were the underlying factors of success in this arrangement. However, the Director of Materials Management within jospital H_C articulated that the key concern within such an arrangement was that the hospital was completely dependent on a specific supplier. Further, the decision about partnering was based on clinical and financial outcomes that needed to be documented at the outset. Finally, contingencies such as ownership of expired stock and lost or damaged stock arising from this arrangement needed to be discussed by the supply chain partners before entering into such an arrangement.

Due to the concerns outlined above, hospital H_D decided to completely outsource the functioning of its MMD to hospital H_C. Under the "complete" outsourcing arrangement, hospital H_C was responsible for the inventory management functions, negotiating with suppliers, seeking regulatory compliance, reporting to the executive management and developing

appropriate performance measures where applicable. They also liaised with suppliers and represented the department in the internal management meetings in the hospital. This outsourcing arrangement was viable for the larger hospital (hospital H_C) as it consolidated its buying power thereby resulting in economies of scale and scope. Although this arrangement led to several advantages such as decreasing the inventory at hospital H_D and improving efficiency since the processes were handled electronically. However, the "complete" outsourcing arrangement was not immune from several complexities such as complying with a tough regulatory environment. Further, building this arrangement into their relationship was a real challenge because hospital H_C was perceived as a distributor rather than a "colleague" in the same industry.

The discussion above highlights that a series of issues need to be considered when a hospital decides to completely outsource its MMD to a third party. These issues include contract management, changes in the regulatory climate and level of trust between the participating organisations.

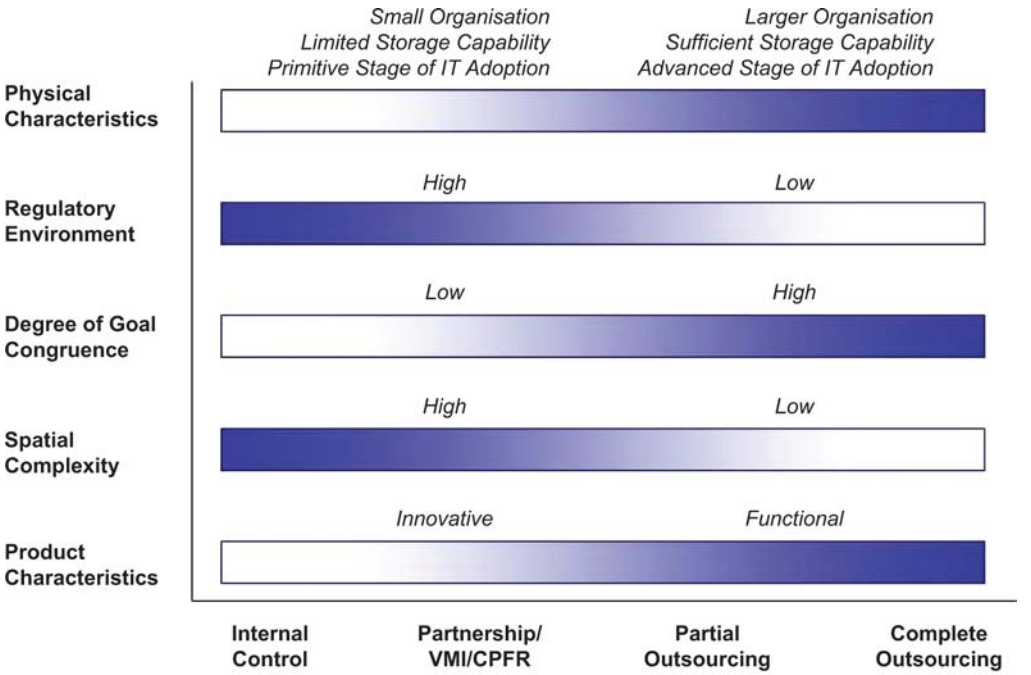
Contingent factors

The results of this study identified several contingent factors as key variables influencing the development of collaborative initiatives with supply chain partners. The specific contingent factors that we identified in the context of our study are product characteristics, spatial complexity, degree of goal congruence between supply chain partners, the role of the regulatory environment and physical characteristics of the organisation. Some of these characteristics are based on a study by Danese (2007). Figure 3 summarises all these factors.

The key contingent factors are:

- *Product characteristics*. The results of this study demonstrated that the VMI system functioned very effectively for items within the MMD such as prosthetics, sutures and stents because of the inherent complexities embedded in these items. These included the need for these items to be supplied in a variety of sizes/dimensions, were of a high dollar value, had low turnover rates and their usage was a function of the patient mix. Although these products exhibited characteristics of functional as well as innovative products (Fisher, 1997), they were skewed in favour of being functional because the elasticity of the demand and supply for these products are relatively higher compared to regular pharmaceutical products. Thus, these products functioned as ideal candidates for the application of collaborative arrangements such as VMI or collaborative planning, forecasting and replenishment (CPFR) systems. This concurs with the findings of Danese (2007) who suggests that products with high demand and supply elasticity would result in supply chain partners to these items more likely to engage in collaborative initiatives. As Figure 3 highlights, functional products are ideal candidates for developing collaborative arrangements with supply chain partners which is strongly supported within the context of this study. This is because manufacturer M_C had implemented the VMI system for intravenous fluids (classified as functional products by the interviewees in the organisation) with hospitals. Further, MMD within specialist hospitals such as hospital H_D were more receptive to collaborative and outsourcing arrangements with supply chain partners in the supply chain because these hospitals were able to predict their patient mix since patients were admitted for similar surgical operation needs. Finally, pharmacy departments were not interested in relinquishing control over drugs which they perceived as life saving, had short shelf lives and where the expiry date was really critical as it would impact patient safety.
- *Spatial complexity*. Spatial complexity refers to the geographic distance between organisations. The problem of high spatial complexity, where a regional hospital is located at a considerable distance from the manufacturer or the wholesaler/distributor, is that this poses significant risk within the healthcare domain because a breakdown of supplies can lead to severe consequences. The literature highlights that organisations exhibiting high spatial complexity are less likely to engage in collaborative initiatives such as JIT, VMI and CPFR (Rivard-Royer *et al.*, 2002; Danese, 2007). The issue of spatial complexity is particularly relevant within the Australian context where there is significant distance between regional hospitals and key wholesalers/distributors or manufacturers. This study highlights this issue as hospital H_E, which represented the regional hospital, obviously had a higher spatial complexity and was not receptive to developing collaborative arrangements such as VMI.
- *Goal congruence and degree of trust/commitment between organisations*. This study suggests that the degree of collaborative arrangements between two organisations is a function of the level of trust/commitment and goal congruence between the two organisations. Therefore, when two organisations have high goal congruence as well as trust/commitment, they are more likely to engage in collaborative programs (see Figure 3). There was resounding support for these factors throughout the study. For example, the success of the "ward box" system was contingent on the fact that the wholesalers/distributors had sufficient stock because stock-outs can have fatal consequences in the pharmaceutical hospital supply chain. Further, implementation of the VMI system between the manufacturers and hospital (pharmacy departments) was unlikely because of the limited amount of trust between these entities. This limited trust stemmed from the fact that both these entities had divergent sets of objectives guiding their supply chain strategies, with the hospitals' interest in patient safety whereas the manufacturers were driven by financial objectives such as improving cash flow and justifying returns on investment. As is evident from this study, the hospitals were most comfortable outsourcing their MMD to another hospital, which testifies to the fact that goal congruence is a crucial factor while implementing a collaborative initiative such as VMI.
- *Regulatory environment*. The regulatory environment plays a significant role within the pharmaceutical healthcare context and could prove problematic if contracts were inflexible to changes in the regulatory environment. Therefore, products that require high regulatory environment would be less receptive to developing collaborative arrangements with supply chain partners compared to products that do not face the same regulatory constraints (see Figure 3). This fact resonated within the context of the current study with MMDs that did not face the same regulatory environment. The MMDs were

Figure 3 Contingent factors affecting the development of collaborative relationships across the healthcare/hospital supply chains



Source: Adapted from Danese (2007)

therefore more receptive to collaborative arrangements right from VMI to complete outsourcing.

- *Physical attributes such as the size of the hospital, availability of storage space and the stage of IT adoption*. As Figure 3 shows, larger hospitals that have sufficient space are ideal candidates for implementing VMI programs. This is essentially because large hospitals have sufficient wards thereby resulting in economies of scale for the third party entering into such an arrangement. This surfaced within the context of this study as wholesaler/distributor W/D_B had implemented the "ward box" system for hospital H_A. Further, since the MMD at hospital H_C was the most progressive in its uptake of e-business technologies, hospital H_D was comfortable with outsourcing its MMD to this hospital.

Discussion

Summary of findings and propositions

The findings of this study suggest that a hospital can engage in myriad collaborative arrangements with supply chain partners to manage inventory. These arrangements lie on a spectrum ranging from internal control to complete outsourcing (see Figure 3 for more information). A hospital may choose to retain complete internal control over its distribution and inventory management functions. It can also enter into collaborative arrangements with others using systems such as VMI and CPFR.

In the context of the current study, wholesaler/distributor W/D_B had implemented the "ward box" system with several hospitals. As a partial outsourcing system, a small fee was charged by this wholesaler/distributor as the third party for managing the procurement, warehousing and inventory management functions, but the price negotiations were conducted by the hospital and the supplier. The third party also had its own personnel who distributed the goods within the specific ward/department in the hospital. The critical success factor for this arrangement is that there was complete compatibility in information systems between the third party and the hospital pharmacy.

A similar type of arrangement also existed between the MMD at hospital H_D and wholesaler/distributor W/D_A. Under the complete outsourcing system, the hospital outsourced the functioning of the entire department to the wholesaler/distributor, which, as a third party, conducted activities including procurement and inventory management functions, seeking regulatory compliance and reporting to the executive management in the hospital. This arrangement, as exhibited by the MMD at hospital H_D, was replicated by the MMD of hospital H_C.

In developing and implementing collaborative arrangements, supply chain partners need to be aware that there are a range of contingent factors that can influence the success of these arrangements. Danese (2007) discusses five contingent factors (i.e. goal of the CPFR initiative, product/market characteristics, supply network's physical and relational structure and the stage of CPFR development) to explain the application of the CPFR system by conducting seven case studies across diverse industries. We refined and extended Danese's list and showed that these factors also apply to healthcare supply chain context. These five factors are:

1 product characteristics;
2 spatial complexity;
3 degree of goal congruence;
4 regulatory environment; and
5 physical characteristics.

Further, based on an analysis of these contingent factors (see Figure 3 for summary); we propose that these five factors act in particular ways.

For the first contingent factor, i.e. product characteristics, we propose that:

P1. The characteristics of the product have an influence on the type of collaborative inventory management arrangements that are adopted between supply chain partners.

Product characteristics can be either innovative or functional. It is proposed that:

P1a. Innovative products are better managed with internal control methods.

P1b. Functional products are better managed with methods that employ collaborative arrangements with trading partners.

The second contingent factor identified is spatial complexity. We propose that:

P2. Spatial complexity of a supply chain partner has an influence on the type of collaborative inventory management arrangements it adopts with others.

Spatial complexity can be high or low. It is proposed that:

P2a. A supply chain partner with high spatial complexity can better manage inventory with internal control methods.

P2b. A supply chain partner with low spatial complexity can better manage inventory with methods that employ collaborative arrangements with trading partners.

For the third contingent factor, i.e. degree of goal congruence, we propose that:

P3. The degree of goal congruence has an influence on the type of collaborative arrangements that are adopted between supply chain partners.

Degree of goal compatibility can be either low or high. It is proposed that:

P3a. Supply chain partners with low degree of goal congruence can better manage inventory with internal control methods.

P3b. Supply chain partners with high degree of goal congruence can better manage inventory with methods that employ collaborative arrangements with trading partners.

For the fourth contingent factor, i.e. regulatory environment, we propose that:

P4. The regulatory environment has an influence on the type of collaborative arrangements that are adopted between supply chain partners.

Regulatory environment can be either high or low. It is proposed that:

P4a. In highly regulatory environments, supply chain partners can better manage inventory with internal control methods.

P4b. In low regulatory environments, supply chain partners can better manage inventory with methods that employ collaborative arrangements with trading partners.

For the fifth contingent factor, physical characteristics, we propose that:

P5. The physical characteristics have an influence on the type of collaborative arrangements that are adopted between supply chain partners.

Physical characteristics of a supply chain partner can be limited (small organisation, limited storage capability and primitive stage of IT adoption), or, at the other end of the spectrum, these can be abundant (larger organisation, sufficient storage capability and advanced stage of IT adoption). It is proposed that:

P5a. A supply chain partner with limited physical characteristics can better manage inventory with internal control methods.

P5b. A supply chain partner with abundant physical characteristics can better manage inventory with methods that employ collaborative arrangements with trading partners.

Contributions

This study makes a number of useful contributions to literature on the subject of inventory management in hospitals. The first key contribution is that this study extends earlier work conducted within the VMI domain. Earlier studies (Disney and Towill, 2003; Vigtil, 2007) have been based in manufacturing industry, and it is not clear whether the VMI could apply to the healthcare sector. Mustaffa and Potter (2009) speculate on this, but no clear evidence exists. In this study, we have shown that the "ward box" system, a variant of the VMI system, could apply. Further, we have shown how this works by discussing the application of the VMI system downstream in the supply chain particularly from the hospital's perspective.

A further key contribution of this study to the literature is that it builds on a recent study by Danese (2007) on contingency factors in several ways. Firstly, since the focus of this study was the hospital supply chain, it provides a discussion on the key contingent factors identified by Danese (2007) and applies them within the context of the current study. Secondly, it adds other contingent factors such as the regulatory environment and the degree of goal congruence to the list of factors proposed by Danese (2007). Finally, Danese's (2007) study was principally focused on implementation of CPFR; our study develops a spectrum of the collaborative arrangements within the pharmaceutical context ranging from internal control to complete outsourcing and discusses the role of specific contingent factors that facilitate an organisation's participation in these collaborative arrangements.

We also contribute methodologically. Previous studies investigating collaborative arrangements in the healthcare supply chain have either used the pharmaceutical manufacturer as the focal organisation in the network (e.g. Danese, 2006), or two echelons in the supply chain (Mustaffa and Potter, 2009). In contrast, our study takes a different approach. Our study extends the literature by discussing the application of the collaborative relationships downstream in the chain where the hospital is the focal organisation in the chain.

Limitations and future research opportunities

Although we have added to the literature in a number of ways, there are some other aspects that could be investigated in future research. First, the impact of government regulatory agencies and group purchasing organisations is not clear. They could play a proactive role in accelerating the adoption of strategies such as VMI by relaying information between parties and encouraging the hospitals to share crucial market intelligence data. They do not appear to do so currently. Therefore, the exact roles and influences of these agencies require further examination. Second, the pharmaceutical hospital supply chain appears to be highly fragmented. This prevents the emergence of leaders who could guide and co-ordinate the actions of all players in these supply chains. Further research is required in terms of exploring how supply chain leaders can emerge. Third, since there was an absence of collaborative arrangements between the manufacturer and the wholesaler/distributor, there is a need for this relationship to be explored. Fourth, there is obvious disparity between MMDs and hospital pharmacy departments. The former appear to be a lot more proactive about developing collaborative arrangements with supply chain partners than the latter. While this study provides insights into this, more research is required, particularly if the practices and attitudes within MMDs are going to be transferred to hospital pharmacy departments. Specifically, it would be worthwhile investigating how contingent factors such as expiry dates for products impact developing collaborative relationship with trading partners. Fifth, since the hospitals in this study had not outsourced their information systems, therefore a future avenue of research would be to conduct in-depth case studies with hospitals that had outsourced this function and identify how doing so has enhanced a hospital's willingness to engage in a VMI partnership with trading partners. Finally, this paper has presented several propositions. These could be tested in larger scale empirical studies. The generalisability of these findings could be improved in future studies if they are conducted in other industry sectors and country settings.

Conclusion

In this paper we set out to study the inventory management practices of participants in healthcare supply chains. Specifically, we sought answers to two questions:

1 How do different actors in the hospital supply chain collaboratively manage inventory?
2 What contingent factors influence the development of collaborative inventory management practices?

We used a case study design involving a network of ten organisations from the healthcare sector from Australia to answer these two research questions.

We established that a myriad number of arrangements are used, ranging from the traditional arm's-length purchasing of items at one end, to sophisticated systems that involve deep engagement of parties using systems such as VMI at the other end. Further, we found that a number of contingent factors influence the type of arrangement that is eventually used by participants in a supply chain. These include product characteristics, spatial complexity, degree of goal congruence between supply chain partners, the role of the regulatory environment and the physical characteristics of the organisation.

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Appendix. Interview protocol

Background information

- What is your role in the organisation and what responsibilities does it include?
- What is the management structure of your organisation?
- Where does your organisation fit within the healthcare supply chain?

- What products/ services are offered by your organisation? How many Stock Keeping Units does your organisation have?

Inventory management questions

- Does your organisation have any strategies in place for managing inventory?
- What are the most crucial issues facing organisations managing inventory in the healthcare sector? How is your organisation using information technology for managing inventory?
- Does your organisation adopt a different approach to managing inventory for functional and innovative products?
- Does your organisation use any collaborative approach with trading partners to managing inventory (for example VMI, CPFR, or complete outsourcing)?
- How is this collaborative initiative to manage inventory actually implemented with trading partners?
- What do you perceive are the important contingent factors for the success of a collaborative arrangement with your trading partners?

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