HEALTHCARE SUPPLY CHAINS: A CASE STUDY OF HOSPITAL-VENDOR COLLABORATIVE PRACTICES

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Abstract

The paper discusses the characteristics of healthcare supply chains, and puts particular emphasis on the implementation of VMI/CMI in this sector specific context. By the means of case study research the paper provides empirical data on the benefits of the above collaborative practices for both the hospital and vendors. The paper contributes to the stream of research on VMI/CMI in the healthcare sector, where limited research attempts have been conducted so far. In contrast to other surveys this case study shows that specific and measurable cost reductions exist, in addition to other improvements such as better control over the inventories, and also in reduction of administrative work. Results obtained may be also relevant to other hospitals and vendors and as they can form a basis for comparisons.

Keywords: healthcare supply chains, hospital, CMI/VMI, collaboration, Greece

1. Introduction

The healthcare sector is facing major challenges nowadays. Healthcare providers and institutions are under an increasing pressure to deal with a number of inefficiencies, in order to achieve an optimum balance between improvements in quality healthcare services and cost effectiveness (Norris, 2002, Di Martinelly, Riane, and Guinet, 2009; Dillon and Prokesch, 2010). Supply chain costs can account for over one-quarter of a hospital's operating budget, while the healthcare industry could significantly improve its ability to deliver quality healthcare products and services to consumers and save as much as $11 billion (CSC Consulting, 1996). Many authors (Towill, and Christopher 2005; Schneller and Smeltzer, 2006, de Vries, 2011; Min, 2012), have pointed out that saving opportunities are not currently exploited by organizations due to supply chain inefficiencies, such as ineffective inventory control and materials management, inadequate purchasing orders, and distortion of information flows involved in the transport and delivery of supplies to the healthcare providers.

A key problem creating these inefficiencies is the lack of collaboration among healthcare entities. Collaboration at various levels in the chain has been recognised as a way to construct ever more efficient and responsive supply chains, in order to deliver exceptional value to customers (Matopoulos et al*.,* 2007). Examples of collaborative practices are Vendor Managed Inventory (VMI) or Co-Managed Inventory (CMI), which is a variation of VMI. In the literature a plethora of studies exist, particularly for the VMI practice. For example, Chatzipanagioti, Theodori, and Vlachos*,* (2007) compared VMI system performance to traditional retailer managed inventory discussing also the technological infrastructure required. In a similar vein Zhang, Zhang and Guo (2008, p. 91), compared the performance of VMI with the performance of decentralised inventory policy suggesting that: *"under a certain cost condition, although VMI likely reduces the vendor's profit, it, compared with decentralised inventory policy, will decrease the retail price and consequently brings higher expected profit level for the buyer and the whole supply chain*". Borade and Bansod (2012) presented the differences in the implementation of VMI practices between the manufacturing and the services sectors. Many studies have also taken place in other sectors such as the automotive or the electronics, but only a few studies have been conducted in the context of the healthcare sector. Against this background, the aim of this paper is twofold: to increase the understanding of the nature of collaborative practices in healthcare supply chains and to provide empirical evidence on the impact of hospital-vendor collaborative practices by comparing reported and actual outcomes related to these practices. More specifically we try to answer the following research questions:

- RQ1. What is the real impact of the implementation of CMI?
- RQ2. What are the factors enabling the implementation of such practices in a hospital environment?

The rest of the paper is structured as follows. In the next section, the specific characteristics of the healthcare chain are discussed so as to provide an understanding of the complexities of the sector. Next, an analysis of the characteristics, benefits, and requirements of VMI/CMI is provided. Finally, the case study is presented and the findings and their implications are discussed.

2. Healthcare supply chains

The healthcare supply chain shares a number of similarities with other chains, not only in terms of processes (e.g. procurement, warehousing, distribution), but also in terms of discerning customers and management structures (Walters and Rainbird, 2007). There are also differences in the chain that are related to the specific characteristics and requirements of the sector. In general, healthcare supply chains are very complex, diverse, and dynamic. That complexity arises from the numerous companies and organizations participating in the chain, which are involved in many interactions across the entire chain. Burns and Wharton School Colleagues (2002), provided an extensive presentation of healthcare entities by grouping organizations performing similar tasks. They proposed five major groups of entities: payers (e.g. government, employers, or any other individuals), fiscal intermediaries (e.g. insurance companies, health maintenance organizations, pharmacy benefit managers), providers (e.g. hospitals, divisions, physicians, and facilities such as physician offices, medical and ambulatory surgical centres and pharmacies), purchasers (e.g. resellers such as pharmaceutical wholesalers, medical surgical distributors, product representatives, independent contracted distributors, group purchasing organizations) and producers (e.g. pharmaceutical manufacturers, medical device manufacturers, medical surgical manufacturers, providers of information technology services and manufacturer of capital equipment). In addition, many different processes, tasks, intermediaries, and interfaces take place in each entity.

Much of this complexity is also related to the focal entity, the hospital and the numerous internal independent divisions/departments, pharmacy store(s), and hospital staff. It is worth noting that the hospital management has limited possibilities to control production as it is driven by medical specialists who, nevertheless, do not manage that process (Vissers, Bertrand, and de Vries, 2001). Hospital staff is often responsible for adding complexity and inefficiency in the healthcare system. For example, as Kelle, Woosley, and Schneider (2012) argue the decisions on the prescribed drugs by physicians, pharmacists/pharmacy directors are not always well aligned due to their specific "product preferences". This situation is causing excessive variability, huge product portfolio ranges and minimizes the possibilities for stock reduction, improved inventory control and streamlined purchase practices. Diversity arises, as a result of the differences among the organizations or the individuals involved, in terms of human and financial capital, as well as processes followed and departmental or unit goals. In many occasions, different departments or divisions or even different people within the same healthcare system, have different value drivers or even different goals.

Differences occur as a result of the distinct healthcare service or product characteristics and respective physician or management practices. Similar to Fisher's (1997) suggestions on the need for adopting multiple supply chain designs, Towill and Christopher (2005) argue that some treatments such as hernia repairs need dedicated pipelines ("lean" operations, focusing on waste removals) whereas others need to be more broadly based and responsive, hence the need for agility (time sensitivity and flexibility). Mustaffa and Potter, (2009) refer also to distinctive characteristics in the distribution part of the chain, particularly from the wholesaler to the hospital namely: shrinking product lifecycles, small operating profit margins, forecasting difficulties and lack of supply chain education.

In terms of product differences and based on the categorization proposed by Singh (2006) and by the Greek Ministry of Health and Social Solidarity (3580/2007 Law) the following distinct supply chains, in terms of supplies, can be identified: Pharmaceutical, Medical-Surgical supplies, Medical Devices, Health Aids (e.g. bandage, syringe), Office supplies (e.g. printer cartridges, print paper) and Clothing supplies (e.g. uniform, sheets, towels). Each group of supplies has specific constraints, and is triggered by different demand patterns. There are other flows that often cut across entire national healthcare systems. The blood or transplant supply chains for example, from donors to patients, may include collection, testing, production/processing, storage and transportation to various hospitals and

health care centres wards and operating rooms (Rytila and Spens, 2006). Finally, the dynamic character of that chain could be explained by the very "uncertain" nature of the sector related to difficulties in predicting medical, blood and pharmaceuticals supply and consumption, but also due to policy changes (Mustaffa and Potter, 2009; Samuel et al. 2010). Demand characteristics require healthcare organizations to be both efficient (in the case of products with predictable demand) and responsive (in the case of transplants, pharmaceuticals, medical and surgical supplies with an unpredictable demand). The number of products and relevant demand of those products varies greatly from one patient care unit to the other. Against this background, demonstrating the benefits emanating from building collaborative relationships within the entire healthcare chain becomes a necessity and this is the focus of this paper.

3. Collaborative practices in the healthcare sector

VMI / CMI are forms of co-operation between a vendor and a customer originated more than two decades ago in the grocery industry aiming to achieve performance improvements in the management of inventories. In the following paragraphs, a presentation of the expected benefits and requirements are provided, as well as specific insights and issues arising from VMI/CMI implementation in the healthcare sector.

3.1. Characteristics, benefits and requirements

The basic idea of VMI/CMI is that the vendor manages and takes full (VMI) or joint (CMI) responsibility for inventories. The fundamental difference between CMI and VMI is that the customer maintains responsibility for the replenishment in CMI by revising and confirming proposed orders while this responsibility is transferred to the supplier in VMI under the control of a pre-established agreement. In both cases the customer and the supplier share inventory and sales related information, which are transmitted from the customer to the vendor who then executes stock replenishment or forecasts data for future stock requirements. According to Kaipia, Holmstrom, and Tanskanen (2002), the fundamental change in these practices is that the ordering phase of replenishment is abolished, giving to supplier both authority and responsibility to take care of the entire process. Similarly, Vigtil (2007), describes VMI as: *"an untraditional concept of allocation of responsibility in the replenishment process"*. In terms of benefits, such collaborative practices can increase the overall supply chain performance by decreasing inventory levels, improving customer service levels, reducing order cycle and increasing fill rates (Waller, Johnson, and Davis, 1999; Cachon and Fisher, 2000; Yugang, Liang, and Huang, 2006; Yao *et al.,* 2007).

Reducing inventory levels in healthcare is critical as inventories are one of the major sources of inefficient allocation of financial and human resources. Hospitals tie up as much as one third of their budgets in inventory and the required labour to manage it (Oliveira and Nightingale, 2007). Surprisingly, nursing shortages is also an issue related to inventories, since nurses sometimes take decisions on inventory levels, instead of providing their services to patients. Inventory management could represent a major source of inefficiency which could be potentially reduced by using VMI/CMI. This is becoming very common in many healthcare systems. In Greece, hospitals are facing an estimated nursing shortage (approx. 6.000 nurses), while in the United States, the nursing shortage will reach 600.000 by 2020 (Oliveira and Nightingale, 2007).

VMI/CMI is very likely to confront one of the more important inefficiencies in the healthcare sector, the existence of secret inventory stashes. Many physicians, nurses of even heads of departments or clinics tend to maintain higher and "secret" inventories, in order to avoid stock-outs. Lee and Chu (2005) argue that the shift of the responsibility for inventory-carrying and replenishing from the customer to the supplier is expected to create an extra burden for the supplier; thus, most of the proposed benefits of VMI/CMI implementation are more likely to be realized by downstream supply chain members notwithstanding that the VMI/CMI implementation is beneficial for the supplier. For example, it gives the supplier more time to react, it brings benefits in the production planning process and in inventory management, it minimizes lost sales and finally, it improves delivery service in supplier's customers not engaged with VMI (Kaipia, Holmstrom, and Tanskanen, 2002; Lee and Chu, 2005; Kaipia, 2008; Mustaffa and Potter, 2009). Table 1 provides a brief presentation of the benefits of VMI/CMI.

Table 1: VMI / CMI benefits

VMI / CMI benefits	
For the Customer	**For the Vendor**
Reduces or eliminates purchasing activities and wasted time in non value added processes	Improved visibility of customer demand enabling the supplier to postpone manufacturing or to postpone other decisions (e.g. purchasing stock)
Enables focus on strategic supplier management and process development	Improved visibility translates to added flexibility in production scheduling
Reduces or eliminates order backlog	Improvements in the distribution process (increase transportation efficiency)
Improvements in inventory turnover and reductions in stock outs	Enables the provision of increased levels of service to the customer

3.2 Implementing VMI/CMI in the healthcare sector: A research framework

Despite the expected benefits and results reported in several cases, VMI/CMI implementation is a demanding task (Kaipia, Holmstrom, and Tanskanen, 2002) and Muckstadt et al. (2001) comment that the actual results of VMI/CMI implementations are often disappointing. What are the reasons for this? First of all, both the vendor and the customer may be unwilling to share information or may be incapable of doing so as a result of incompatible information systems. Lack of trust represents an additional constraint factor for the implementation of VMI/CMI practices (Danese, 2006). The healthcare sector is also facing quite distinct inventory-related problems, which add complexity in the VMI/CMI implementation making thus the realization of benefits a demanding and difficult task. A stock-out in a hospital pharmacy is not at all comparable to a stock-out in a retailing store and the responsibility of replenishment is much critical in that chain.

This has been proved to be a very important reason in our case study that has driven the hospital under research to implement the CMI practice instead of VMI. Limited research has been reported for the implementation of VMI/CMI in the healthcare sector, particularly for its adoption. For example, Oliveira and Nightingale (2007) emphasized the relationships of two hospitals in the US healthcare with a leading healthcare vendor and indicated significant improvements in areas such as product availability, data visibility and labour use reduction for inventory management. Another successful VMI implementation was reported by Tsui et al. (2007) in an Australian hospital. Despite an initial surge of stock holding, the one-off savings from stock reduction was maintained 18 months after implementation. However, it was found that manufacturers have lagged behind in-fill rates compared to wholesalers. Improved data exchange between wholesalers and manufacturers was expected to reduce stock holding across the entire supply chain. Another study by Claasen et al. (2008) showed that purchasing managers who invest in the relationship with the supplier and have a good IT infrastructure are more likely to get better results from a VMI implementation. Furthermore, the study revealed that VMI is often implemented with wrong expectations about the benefits: most managers expect major cost reductions when implementing VMI. Instead, VMI often results in some cost reductions but benefits can be expected from improved service levels and improved supply chain control. In another recent survey by Bhakoo, Singh, and Sohal, (2012) it was found that collaborative arrangements and respective perceived benefits amongst supply chain partners can vary significantly due to several contingent factors such as: product characteristics, spatial complexity, regulatory environment, goal congruence and degree of trust/commitment between organisations and physical attributes (e.g. hospital's size, availability of storage space, stage of IT adoption).

Based on the previous analysis and particularly the work by Claasen et al. (2008) and by Bhakoo, Singh, and Sohal, (2012) the following framework was developed (Figure 1). The framework links vendor's-hospital's perceived CMI impact with the forces affecting its implementation. The forces have been classified to extra-organizational ones and intra-organizational ones. Extra-organizational forces include those that are not related directly to the hospital such as: external pressures, relationship quality, and vendor's capability. The external pressures include pressures from the government or the competition, which could act as a catalyst in implementing the VMI/CMI practices. Relationship quality is related to the actual ability to collaborate with the suppliers, by exchanging and sharing information with trust and without the fear of facing opportunistic behaviour. Vendor's capability is related to readiness and availability to provide such a service to the hospital. Intra-organizational forces include the capability to recognize potential benefits and the ICT capacity which will facilitate the control of

inventories. Finally, operational capacity is related to changes and adjustments that are needed to streamline the implementation process.

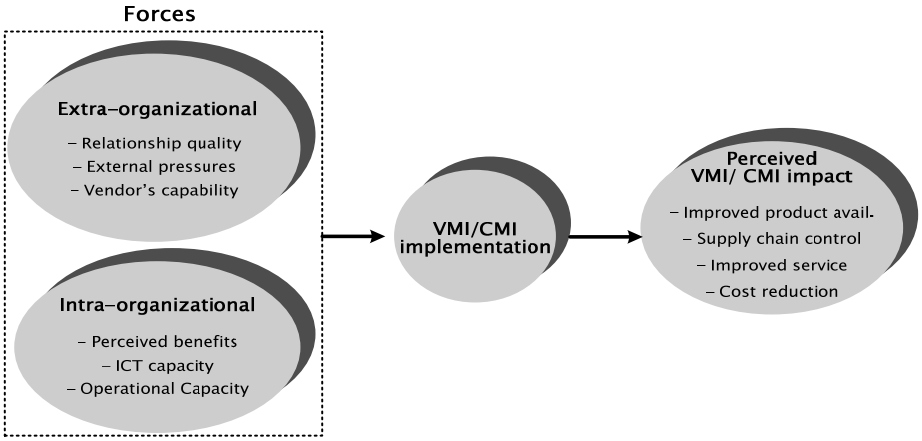

Figure 1: A conceptual framework of forces affecting implementation and impact of VMI/CMI

4. Research Context & Method

4.1 An overview of the Greek healthcare supply chain

The Greek healthcare supply chain (GHSC) is characterized by increased complexity and it is quite fragmented. In terms of finance, following the European taxonomy of health systems, Greece presents a mixture of public contract and public integrated models financed by a mixture of social insurance contributions, general taxation, and private payments (Yfantopoulos, 2007). Essentially, patients finance the system both directly (charges, private insurance contribution) and indirectly (taxation). It is estimated that 10% of the GDP (more than the European average) is allocated making Greece the first country in Europe and the second in OECD countries in terms of expenditures (Yfantopoulos, 2007). In terms of healthcare facilities, 340 hospitals exist with 40% of them being public, but holding 70% of national bed capacity. Public hospitals and National Health Service (NHS) facilities (e.g. regional clinics), are provided with hospital supplies by more than one thousand companies. It is estimated that there is a range of around 500.000 medical products currently in the GHSC. In terms of medicines, nearly 11.000 different products exist and nearly 40% of the annual NHS budget is allocated to medicine supplies (Ygeianet, 2007). The vast majority of these products is produced by 70 pharmaceutical companies, and then are distributed by a network of private (112 companies) and other distributors (27 companies). In fact, Greece has one of the biggest numbers of pharmaceutical wholesalers (GIPR, 2004; IPF, 2005). Figure 2 provides a schematic representation of the Greek healthcare supply chain.

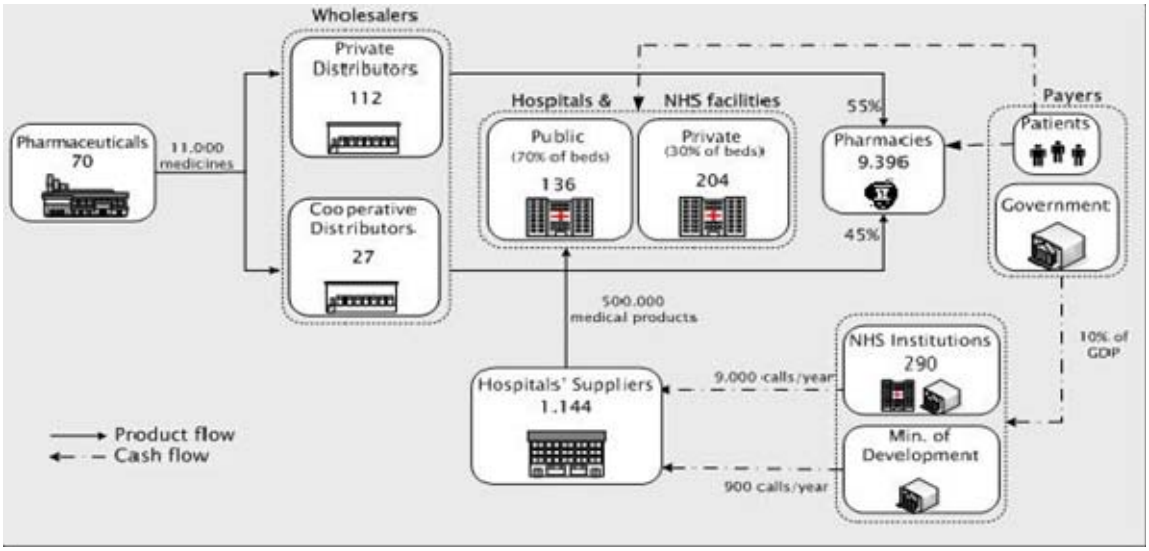

Figure 2: A schematic representation of the Greek healthcare supply chain

The Greek healthcare sector has recently been under a significant pressure to become competitive and particularly cost effective. Greece has enjoyed a national health care system since 1983 (1397/1983 Law). The Greek health care sector remains highly centralised with the Ministry of Health & Welfare exercising control and supervision over all aspects of health care. Since 1983, several reforms were applied in the system rather unsuccessfully. The 2001 reform established regional health care systems aiming to provide health care policies for their regions, map local population needs, decide upon the establishment of new hospital departments and their potential merging or closure, determine human resource needs, authorise health care services and budgets, supervise supplies and commissions for health care services and develop qualitative and quantitative indicators to measure the effectiveness of health care services (2889/2001 Law) (Tountas, Karnakis, and Pavi, 2002; Michailidou, 2003). The latest reform took place in 2007 (3580/2007 Law) where the focus is on achieving performance improvements in the healthcare supply chain by managing inventories better. According that reform, a new Procurement Committee is established which will have responsibility for planning procurement practices and inventory controls across the entire Greek NHS. This new initiative is expected to put an end in a procurement and logistics system of autonomy, anarchy and inefficiency and to streamline the respective operations. According to the Greek Ministry for Health and Welfare, each year nearly 300 NHS institutions conduct 10.000 calls for hospital supplies suggesting that the implementation of any practices or initiatives (such as VMI/CMI) can be critical.

4.2 Research method

We chose the case study method in this research and specifically the "single case design" (Yin, 1994) with multiple units of analysis. This method was preferred since it enables a more descriptive and exploratory approach allowing for more rich insights into the research object (Yin, 1994; Miles and Huberman, 1994). In order to collect data, an interview protocol has been developed which linked the questions to the issues identified in the literature (see Appendix). In particular, the first part of the interview protocol included questions regarding the hospital and distinct characteristics in terms of hospital supplies, replenishment and order strategies followed. The second part dealt with the relationship between the cardiology department (the unit of angioplasty in particular), and the vendors which are currently collaborating with the inventory management processes. In this part, a number of issues regarding benefits, obstacles and evolution of relationships were explored. The same interview protocol (after adaptation) was used for interviews with two vendors. The use of collaborative practices with vendors is not rare in a hospital. A number of departments/units such as neurosurgery, orthopaedic surgery, plastic surgery, ophthalmology, in addition to angioplasty have put in place similar practices.

However, in this research emphasis is placed on the angioplasty unit from the cardiology department, where supplies have very short life and are of high value. It was also decided not to examine VMI/CMI practices for drugs for two reasons: first of all, most drugs do not have as short life as other supplies, thus there is no danger for them to expire. Secondly, on average, most drug prices are significantly lower in comparison to other supplies. In total, five people were interviewed. More specifically, at hospital level, three semi-structured in depth interviews took place with one warehouse manager and one procurement manager of the cardiology department. The initial analysis of the data shows that there was some lack of understanding regarding the financial benefits of VMI/CMI, which resulted in an additional interview with the director of finance in order to provide additional financial evidence and estimations. At the vendors' side, interviews took place with two managers of two vendors dealing with the most critical supplies in diagnostic and interventional cardiology such as endeavour sprints, balloon dilatation catheters, coronary guiding catheters, and coronary guide wires. The duration of all interviews was less than an hour and these were conducted during three visits to the hospital and two visits in vendors' offices. The hospital was selected based on three basic criteria: firstly, it was the size of the hospital. A big hospital was selected having 2.000 staff, a capacity of 800 beds, and various activities. The hospital is made up of numerous clinics in medical areas such as renal and haemodialysis, oncology, inpatients surgery, neurology, rheumatology and dermatology and makes use of the latest specialist equipment. An ERP system was installed and this would facilitate the data collection and exchange.

The second criterion was related to the legal character of the hospital. The hospital represents the country's largest legal entity of private law in health care, operates under the control of the Ministry and is managed by nine board members. It was expected that this non-public hospital would be more motivated to follow current management practices in order to achieve performance improvements. The last criterion was data accessibility. In Greece, companies are hesitant to participate in surveys

for confidential topics such as procurement and cost. Vendors, on the other hand, were selected on the basis of their experience in CMI and their close relationship with the hospital in terms of order volume and order value in the unit of angioplasty. The first vendor was founded in 1958 and it represents one of the most reliable, reputable and innovative business specialising in the cardiology, cardiac surgery, vascular surgery and interventional radiology fields. The company has offices in Athens and Thessaloniki, it has 63 employees, and it applies a thorough quality certification system. The other vendor was founded in 1978 and possesses 20% of the Greek market representing foreign Houses for import and sale of hospital equipment. The main medical equipment that the company imports and exclusively distributes includes heart pacemakers, heart valves, angioplasty material, arterial grafts, cardiac catheters, and cardiac surgery material. Staff comprises 60 people and its headquarters are located in Thessaloniki.

5. Empirical Findings

5.1 Understanding the complexity of hospital operations

Table 2 presents the five major categories of hospital supplies such as Health Aids (e.g. bandage, syringe), Medical Devices, Medical-Surgical supplies, Office supplies (e.g. printer cartridges, print paper), and Clothing supplies (e.g. uniform, sheets, towels). For each category, data are provided in relation to various product related aspects such as product portfolio range (number of different items), cost contribution of each product category (as a percentage of total procurement expenditures), delivery frequency, no of suppliers (size of supplier base), lead time (days needed from order until order receipt), inventory management (what is the strategy followed for replenishment), distribution tactics followed (directly from supplier to department or unit, first delivered to the central warehouse of the hospital) and replenishment control and decision (who is responsible for control and setting the order). In Table 2, no evidence for drugs is given and it was decided to avoid variety and complexity.

Table 2: Hospital supplies and distinct characteristics

Product aspects	**Broad categories of Hospital supplies**				
	Health aids	Medical devices	Medical-Surgical supplies	Office supplies	Clothing supplies
Product portfolio range	1.000	100	18.000	200	10
Cost contribution	23%	5%	70%	1%	1%
Delivery frequency	Once a week	Once or twice a year	Every day	Once a year	Once a year
Suppliers' base	15	3	30	2	2
Lead time	1-5 days	1-20 days	1-3 days	1-5 days	1-15 days
Inventory management	Periodic review & replenishment	Periodic review & replenishment	Periodic review & replenishment	Periodic review & replenishment	Periodic review & replenishment
Distribution tactic	Hospital's central warehouse	Hospital's central warehouse	Hospital's central warehouse	Hospital's central warehouse	Hospital's central warehouse
Replenishment control & decision	Centralized	Decentralized (departments)	Decentralized (departments)	Centralized	Centralized

5.2 CMI adoption, implementation and benefits

The unit of angioplasty (cardiology department) was the first one to adopt CMI. It has a product portfolio range of approximately 320 items, most having high value and short life; hence, the decision to implement CMI for nearly 40% of the products was not a difficult one. CMI was implemented jointly with consignment enabling the hospital to be charged only for the materials actually used. For the hospital, the main reason for the adoption of CMI was reduction of expenditures on medical supplies as there were many cases of overstocking by departments. The finance director stated: *"At the opening of the hospital we followed the inventory levels of another similar public hospital of the same size and structure…that resulted in excessive overstocking of some supplies"*. The vendors are visiting the department very frequently and control the level of inventories, as well as the expired dates. In particular, the vendors are informing the department employees for those products that are close to expire. According to the first interviewee from the cardiology department: "we have adopted this policy the last three years and we are now better off in inventory control and we have achieved reductions in administrative work spent in monitoring the warehouse". Regarding potential reduction of stock outs the second interviewee stated: *"stock-outs were never a problem in our unit… but what*

we did achieve to reduce was overstocking". Regarding the financial benefits for the hospital, followed the implementation of CMI, the director of finance mentioned: *"CMI resulted in direct financial benefits, such as a reduction in the number of expired supplies, but also indirect benefits such as wasted working hours of the personnel or capital savings, which are invested elsewhere in the hospital…approximately 10% savings per year in comparison to the past"*. He continued: *"in the past, we used to place big orders to our vendors which often led to many goods that would expire before use"*. Table 3 presents CMI implementation at the angioplasty unit.

Table 3: CMI implementation in the angioplasty unit at a glance

Angioplasty Unit	**Figures**
Key elements	
Product portfolio range	320
Products under CMI	40%
Cost range of the products under CMI	160-2500 € (per item)
Years of CMI in practice	3
Number of Vendors in CMI	10
Annual Financial benefits (for a 10 m. € order)	10% – 1% (savings in employee salaries for those managing inventories) – 3% (savings from expired goods) – 6% (from opportunity costs)

On the other hand, there are some problems in the CMI implementation. One of the first problems reported is that vendors are not very reliable in their visits and often they do not follow visit time windows. An additional problem is that some vendors tend to overstock for some supplies. This is a paradox since the hospital is going to be charged only for the supplies that have been used. A potential explanation is that vendor's salesmen tend to overstock some supplies either to completely eliminate the out-of-stock possibility or to meet sales targets in specific months or periods. According to the director of finance: *"overstocking by vendors takes place in order to avoid delays caused by the bureaucratic hospital machine when placing orders"*. The interviews with managers from vendors revealed that most of the benefits reported in the literature are true. For example, both vendors mentioned that CMI enables them to have a better control of their distribution, warehouses, and suppliers and also provides them with the opportunity to develop more close relationships with their customers (the hospital). In terms of difficulties in the implementation of CMI, it is reported that most of them emanate from inefficient information sharing processes and the bureaucracy in hospital processes. According to one interviewee (vendor): *"one of the most important problems we face is that our client [hospital] often places urgent orders! That is due to drawbacks of the hospital internal order system. It takes many approvals and many signatures for an order to get placed. We can do nothing but satisfy our customer the way he wants it even if they call us in the middle of the night…".*

6. Conclusions

This paper examined the healthcare supply chain and discussed the collaborative practices currently in place. In an era where many healthcare systems in the word are under major critique, understanding the complexity of the system is the first step towards improvement. The paper initially attempted to provide an analysis of the characteristics of the healthcare supply chain and identified sources of complexity and diversity. In particular, the study provided empirical insights from hospital operations. For example, in terms of complexity, five major categories of supplies were identified in the hospital environment with significant differences in terms of product portfolio range, cost contribution, delivery frequency patterns, size of supplier base, lead time, inventory management and distribution tactics and replenishment control and decision. The paper provided also insights following the CMI implementation in a Greek hospital. With increased cost competitiveness, the hospitals have to look at some practices that could improve their performance. Interviews revealed that significant financial and operational benefits exist for both hospital and vendors. The survey by Claasen et al. (2008) suggested that cost reduction is not the most salient benefit of a VMI implementation, but benefits should be sought primarily in service levels and improved supply chain control. In contrast to this survey, this case study showed that for the hospital, there are specific and measurable cost reductions on top of other improvements such as better control over inventories. From a managerial point of view we believe that this paper offers some interesting insights to hospital managers on identifying areas where potential benefits exist and can be captured with rather limited investment.

In terms of limitations, this study was explorative in nature drawing from a single case study, thus the ability to generalise the findings is limited. Also, the vendors that took part in this research were the ones that agreed and as a result the views of a number of other vendors who did not agree to take part in this research are not taken into consideration. Despite these limitations we believe that these preliminary results provide useful insights and explanations that could be helpful to other researchers involved in the understanding of the healthcare supply chain and the uptake of such collaborative practices in hospitals. Not many similar surveys have taken place and we believe that this paper contributes in the body of research by providing rich empirical data. Results obtained may be also relevant to other hospitals and vendors and can form a basis for comparisons. The study could motivate health policy decision makers in order to move towards more effective management methods. Future research should try to further confirm or not the findings of this paper in the context of other hospital departments and units. For example, it would be interested to address whether and how the factors proposed in the conceptual framework affect CMI implementation and benefits in other units. Similarly, it is worth investigating whether or not the benefits of CMI implementation are equally shared among hospitals and vendors and also what are the strategies that could be used to convince vendors in taking part in similar initiatives.

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Appendix: Interview protocol

A.1 Overview

A.1.1 General Hospital information

1. Size of the Hospital (number of employees, bed capacity)
2. Department and units of the hospital
3. Describe the current basic functions of the hospital (e.g. activities outsourced)

A.1.2 Hospital operations and characteristics

1. Describe the challenges that the healthcare sector is facing
2. What are the major weaknesses in terms of operations that the hospital is facing?
3. What are the immediate of future action that you are thinking of undertaking to improve your performance?

A.1.3 Warehouse and inventory management

1. Which are the major product categories in your warehouse, and which are the challenges and problems you face in managing them?
2. What are the characteristics of each product category in term of supplier's base, demand and order patterns?
3. What is the inventory management, distribution, replenishment strategy followed for each product category?

A.2 VMI implementation

A.2.1 General characteristics of the department

1. Describe your department in terms of product portfolio range, product characteristics etc.
2. Motivation for implementing VMI?
3. What was the extent of VMI implementation?

A.2.2 Benefits and problems in VMI implementation

1. Describe the key benefits as a result of VMI implementation?
2. What were the main problems encountered in establishing VMI (e.g. operational changes, ICT requirements etc)?
3. Provide a comparison to previous non VMI status

A.2.3 Analyse the relationship with vendors

1. Discuss the evolution of relationships with vendors?
2. What are the most common sources of conflicts with vendors?