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Evaluating whether end-user consumption is used as the trigger for flow of interventional cardiology medical devices

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ABSTRACT

The core problem, leading to this study, is that inventory in general is pushed onto downstream supply chain links, based on forecasts. The effect is that downstream links are often overstocked and slow to react to end-user pull. This study delved into the triggers for inventory flow of medical devices used on a consignment basis at hospitals within the interventional cardiology medical device industry. There has been very little research conducted on the topic of consignment stock management and the inventory flow of these devices. The study aimed to look for answers around the questions of flow and types of waste possibly present within this industry.

A qualitative research strategy was followed, where interviews were conducted with key role players within the industry. Eight case studies were designed, using interview data collected from leading supply companies and hospital staff members. In order to validate the results, a dynamic buffer management simulation was conducted, using primary data collected in the industry. The simulation followed theory of constraints thinking processes and served as a tool to strengthen the credibility of the results through a process called triangulation.

It was concluded that overwhelming evidence exists, demonstrating that end-user consumption is used as the trigger for flow of interventional cardiology medical devices placed on consignment at hospitals. Replenishment of inventory on consignment was performed to daily pull. However, the core problem is that goods still flow as a result of a forecast. Considerable potential exists to improve flow through the use of a dynamic buffer management approach. Significant forms of waste were found to be present within this industry.

KEYWORDS

Supply chain management

Dynamic buffer management

Information sharing

Supply chain waste

Pull and push policies

Consignment stock management

Theory of constraints

DECLARATION

I declare that this research project is my own work. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration at the Gordon Institute of Business Science, University of Pretoria. It has not been submitted before for any degree or examination in any other University. I further declare that I have obtained the necessary authorisation and consent to carry out this research.

Andries van Rooyen

9 November 2015

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CHAPTER 1: INTRODUCTION TO THE RESEARCH PROBLEM

1.1 Research Scope

The scope of this research was to investigate the various triggers for flow that existed within the interventional cardiology medical device industry. The aim firstly was to establish whether end-user consumption should be used as the trigger for flow of medical device inventory items coming from suppliers and distributed to downstream supply chain links. The study secondly tested whether end-user consumption was used as the trigger for flow of interventional cardiology medical devices. This is where consumption signals came from downstream links that flowed to upstream links and resulted in a trigger for flow. The study thirdly tested whether consignment stock management, which is very similar to vendor managed inventory (VMI), was best practice when managing inventory of interventional cardiology medical devices at catheterisation laboratories (cath labs) within hospitals. The interventional cardiology supply chain was furthermore scrutinised to test whether useful information is effectively shared between supply chain links and whether elements of waste were present.

1.2 Research Motivation – Academic Perspective

Barros, Barbosa-Póvoa and Blanco (2013) identified seven detrimental phenomena present in supply chains. Supply chain wastes as well as the bullwhip effect were two of the seven detrimental phenomena identified. They identified areas for further study to investigate the applicability of their methods to other business sectors. The authors also highlighted that implementation of selected solutions were not part of their study.

Mahapatra, Yu and Mahmoodi (2012) asked for more research to be done studying make-to-stock supply chains in uncertain environments, specifically environments where customer demand is uncertain, erratic, and where manufacturing and distribution lead times are variable. The proposed research study further investigated these areas at length.

Lee, Padmanabhan and Whang (2004) made the claim that sharing of sell-through and inventory data among supply chain links were growing in popularity and that further research needed to be conducted to explore this topic further. This research has been built on these concepts and magnified the possible gains that can be achieved through

the sharing of information amongst all stakeholders along the supply chain. Specific gains can most certainly be achieved when the trigger for inventory flow only occurs at the point of end-user consumption.

1.3 Research Motivation – Business Perspective

Battini et al. (2013) admitted that supply chain management in the healthcare sector is presented with a plethora of challenges. The authors also confessed that healthcare is a less studied setting and that high demand volatility can be listed as one of the reasons for being a neglected area of study. It is believed that healthcare systems paid little attention to inventory management systems. This is apparent when looking at the high levels of inventory present within the system caused by poor stock management practices and poorly calculated safety stock and other inventory buffer levels. Further research in this realm can benefit academia and business alike.

Battini et al. (2013) suggested further research to be conducted looking at lean deployment strategies like waste reduction within consignment stock models. It was believed that information sharing through stakeholder collaborations can lead to seamless material and information flow within the healthcare industry. This research study has explored these aspects further.

Tierney (2015) gave evidence of the perceived benefits, which radio-frequency identification (RFID) inventory solutions have brought to the catheterisation laboratory (also referred to as cath lab) at the hospital where she worked. She talked about benefits like customer demand that has been met, overstock reductions within the hospital as well as decreased spending. High rates of obsolescence, specifically referring to expired stock situations within the laboratory were amongst her biggest challenges, a reality that she faced daily. RFID technology has been believed to be essential in complex supply chains like interventional cardiology medical devices and provided accurate data intelligence as to where stock were located within the supply chain. This research has provided sufficient evidence to be seen as complementary to RFID technologies and helped to add to best practices within this very distinct industry.

1.4 Aim of the Study

The aim of the study was to focus on the end-user's consumption patterns, and whether end-user consumption was used as the only trigger for flow of interventional cardiology medical device stock items. A dynamic buffer management (DBM) simulation exercise was also performed, using specialised modelling software currently available in the marketplace. Both these aspects, the research process as well as the simulation exercise, added to academic and business knowledge.

Goldratt (2009), the originator of the Theory of Constraints (TOC) listed generalised concepts, which Henry Ford complied with whilst designing the Ford motor company's production flow lines. Goldratt talked to these concepts in his document called *Standing on the shoulders of giants* (Goldratt, 2009).

The four concepts were:

1. There had to be a clear focus on improving flow. It was believed that effective flow and consistent lead times had to be amongst the major objectives of any operation.
2. To maximise flow, there had to be ways to avoid overproduction. Overproduction caused inventory to accumulate downstream along the supply chain, which resulted in increased lead times, negatively affecting flow within the system. Practical mechanisms have to be implemented to communicate to the system when not to produce.
3. In order to maximise flow, all local efficiencies had to be abolished. Whole system thinking opposed to local optimisation should have been the focus.
4. There needed to be a focus process in place, which would have helped balance flow (Goldratt, 2009).

This research study has looked at the concepts listed above. The primary aim, however was to focus on the second concept, the concept of flow, and looked for evidence of end-user pull as a mechanism which activated or triggered flow of interventional cardiology medical devices to hospitals. Goldratt (2009) believed that if the supply chain reacted on daily consumption, one would have moved very close to

the ideal picture of what a supply chain should look like. He therefore aimed at removing distortions and added strategic buffers, which allowed for the right inventory to move, based on a pure pull signal coming from the market. The study therefore kept the above-listed conceptual framework into consideration, but specifically focused on one phenomenon. This focus was trying to establish to what degree end-user consumption data was available in the interventional cardiology medical device industry and whether these signals were exclusively used to trigger flow of goods within the supply chain. The availability or non-availability of this data has been used to answer the question whether the data was applied as the only trigger for flow.

Simulation software was used to establish whether a possible gap existed between current practice (status quo) and a possible desired state (simulated scenario). This desired state can also be referred to as the best practice. Daily consumption data, lead times, minimum order quantities, stock on hand numbers as well as some other variables like cost and selling prices were used as inputs into the simulation. Another benefit of the simulation exercise was to identify and also quantify the various gaps that were found. These results will most certainly prove to be useful to businesses with similar operating and stock management models.

This research study has also tested whether lead times within the interventional cardiology medical device industry were relatively stable across the industry and if daily customer demand – better known as end-user consumption – as well as daily inventory information were readily available. In this research, pull policies were investigated in an attempt to establish whether end-user demand was the only pure trigger for flow within the interventional cardiology medical device industry. A variety of factors influencing and persuading cardiologists' decision-making patterns were also explored and lead to interesting insights.

This study investigated whether make-to-stock items like the interventional cardiology medical device industry's products abided by information sharing initiatives like efficient consumer responses, vendor managed inventory, and other swift response mechanisms (Stavrulaki & Davis, 2010). Answers to these questions assisted to establish whether consumption was used as the only trigger for flow in these supply chains.

It is important to note that although this study did not analyse manufacturing operations per se, but focused on the flow of already manufactured products to the point of consumption; manufacturing best practices and related principles have been referred to in the study and were found to be fairly generic. This study examined the relationship

between end-user consumption and how cardiology medical devices' supply chains reacted to these demand signals by means of supply.

1.5 Chapter Summary

This chapter explained what the objectives of this research study were and also looked at the theoretical and business needs for the study. The choice of the research topic was defended and more information was provided on the aim and intricacies of the study. The context of the research was made clear through referring to certain pieces of literature. The literature review pertaining to the research topic will be reviewed in the next chapter. The aim of the literature review will be to gain an in depth look at academia's arguments and debates on the topic, and to present a clear need for this research.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Zhang and Cheung (2011) stated: To a large extent, supply chain management is both a science and an art that together aim at precisely matching supply with demand. They claimed that information sharing among supply chain links as well as advanced order information (AOI) has proved on many occasions to be extremely effective. When they referred to information sharing, they referred predominantly to the exchange of demand and inventory information between upstream and downstream links; more specifically between suppliers or manufacturers and downstream links like retailers. They pointed out the fact that modern technology like electronic data interchange (EDI) has made this transfer of information convenient and simple. It is noted that the transfer of real-time information is perceived to be the most effective mechanism for inventory flow.

2.2 Pull and Push Strategies

The main differences between pull and push policies are relatively simple to understand. Mahapatra et al. (2012) and Spearman and Zazanis (1992) managed to describe the two policies in a succinct manner. They argued that push policies consisted of sourcing, production, and distribution processes, which were purely based on forecasts, also called anticipated demand. Huang, Yuan and Li (2012) argued, however, that forecasts were still important as forecasts provide the necessary input within a pull system in order to determine and adjust the required inventory levels also known as sizing the buffers. Huang et al. (2012) and Nag, Han and Yao (2014) explained that many companies follow push policies in an attempt to satisfy customer service levels. They argued that push systems tend to carry excessive inventory and safety stock levels. Chin, Li and Tsai (2012, p.493) tied the bullwhip effect directly to a push-type system where inaccurate downstream link forecasts resulted in accumulated error demand across the supply chain and resulted in a “snowball effect rolling down the valley”.

Chin et al. (2012), Mahapatra et al. (2012) and Spearman and Zazanis (1992) described pull policies where sourcing, production and distribution processes were only triggered after the downstream links' orders had been received. Nag et al. (2014) characterised pull supply chains as systems where inventory decisions were made in

reaction to real-time market demand, which would have had minimum inventory levels as a result. They did, however, argue that medical equipment supply chains would like to go lean, but due to the fact that it is usually about a matter of life and death when medical products are ordered, they rather focus on high customer care opposed to cost efficiency. They also foresaw an upward trend of medical equipment demand and the result of such a mind-set will be an overstock situation based on push strategies. Theory of constraints principles, however, disagreed with this thinking and believed that by shortening replenishment times, sizing of buffers and reacting to end-user demand only, can allow an inventory pull strategy to be sufficient without jeopardising customer service levels (Schrageheim & Burkhard, 2007).

Mahapatra et al. (2012) and Nag et al. (2014) concurred that hybrid push-pull strategies perform the best in most manufacturing and supply instances. They also argued that pure pull strategies came second and push strategies third. Seen that the interventional cardiology medical device industry has to operate with inventory on hand at the catheterisation laboratories in order to be successful and satisfy customer demand, one can assume that a pull strategy will be best suited. Sousa, Oliveira, Moyano-Fuentes, Sacristán-Díaz and José Martínez-Jurado (2012) however, did not mention push-pull strategies in the study they conducted. They did, however, find a pull strategy to be most effective towards adoption of lean production practices. They also emphasised the importance of balancing production and demand as well as promoting interaction and information integration with customers, which naturally had a reduction effect on inventory levels. Huang et al. (2012) conducted a study in an attempt to establish whether push or pull approaches were better in distribution systems, and their conclusion was that a pull approach is far more superior compared to that of a push approach. However, they did mention that well-defined target inventory levels had to be present along with a replenishment system only reacting on actual customer demand. In their study, they reached their objective of reduced inventory with increased availability of stock to satisfy customer demand. This increased level of availability contributed to increased levels of customer service.

2.3 Waste and Concepts of Lean

Toyota's Chief Engineer, Taiichi Ohno, defined seven types of waste. These types of waste were: stock on hand (inventory), overproduction, time on hand (waiting), transportation, movement, making of defective products, and processing itself (Ōno, 1988). Many of these forms of waste tied in with the research proposal's theme of

keeping inventory and other forms of waste low through maintaining a nimble supply chain, which only reacted on end-user consumption. Doing so, overproduction, overprocessing, waiting times, and a variety of other forms of waste would have been eliminated.

Womack, Jones and Roos (1990) took it a step further and introduced the concept of lean. Christopher and Towill (2000) cited in Nag et al. (2014) drew a useful comparison between agile and lean paradigms. They argued that lean paradigms favour low cost, whilst high availability and responsiveness form part of agile paradigms. Kumar, Choe and Venkataramani (2013) conducted a study on Lean Pull Replenishment (LPR), also referred to by some as Kanban, which was designed to achieve customer service excellence in-line with Six Sigma principles. They viewed Six Sigma as promoting the prevention of defects opposed to merely detecting and correcting them. Kumar et al. (2013, p.87) described a Kanban system as “a means to achieve just-in-time production. It works on the basis that each process on a production line pulls just the number and type of components that the process requires, at just the right time. The mechanism used is a Kanban card. This is usually a physical card, but other devices can be used.” Matzka, Di Mascolo and Furmans (2012) explained that Kanban is a Japanese word, which literally means card or tag and that these tags carry information about the inventory withdrawal, the transport process and the product details. Kumar et al. (2013) claimed that the fundamental philosophy of a lean approach was to reduce the amount of waste within supply chains. They also referred to waste as all non-value-added activities within a supply chain and described value-added activities as those activities that customers are willing to pay for only if it adds perceived value to them.

2.4 Information Sharing and the Bullwhip Effect

Lee et al. (2004) and Stavroulaki and Davis (2010) suggested that information needs to flow freely among supply chain links. They promulgated that these information flows had a direct impact on inventory levels and on production scheduling plans within the supply chain. This research project has attempted to provide enough evidence to prove that information shared amongst supply chain links is an effective way to reduce waste in a variety of forms. This reduction of waste will support the supply chain to be more responsive where product will only flow after receiving consumption signals coming from end-users. It is of fundamental importance that consumption and inventory information gets transmitted on-time to the correct people within the supply

chain. This will ensure that inventory moves at the right time and in the right quantities. According to Goldratt (1990), meaningless information availability is called data and is not helpful at all. The debacle the world finds itself in is that it is drowning in oceans of data, but that useful information is seldom available. He described data as being any answer, while information is the answer to a question asked. In this study's context, the correct answer to the following question is helpful: What must move to the next link today?

Barros et al. (2013) engaged in a study to investigate the factors hindering superior supply chain performance. Seven phenomena negatively affecting supply chain performance were identified and the bullwhip effect was one of them. They described the bullwhip effect as upstream amplifications of demand signals. The bullwhip effect is best illustrated through a simulation called the beer distribution game, which was designed in the 1960s by professors at MIT Sloan School of Management (Kumar et al., 2013). Chin et al. (2012) proclaimed that the bullwhip effect needed to be eradicated within supply chains, as it gave rise to loss of revenue and excessive inventory levels, amongst others. They applied a theory of constraints solution through building inventory buffers at the central warehouse and also changed their approach from a push to a pull strategy. The implementation of dynamic buffers and frequent replenishment made the biggest difference, as missed sales and inventory levels were minimised and return on investment (ROI) was maximised. These changes improved replenishment efficiency significantly. Chin et al. (2012) and Lee et al. (2004) also studied possible distortions in the retail industry. They found that clear distortions in demand information existed and that the orders coming from retailers were not aligned with actual retail sales within the market. These non-alignments are forms of waste. Barros et al. (2013) argued that increases in waste resulted in increased exponential inventory and lead times across the supply chain. These forms of waste can be seen as a result of uncertainty within the supply chain and amongst its links. The result will be notable congestion, especially in periods of high demand.

Barros et al. (2013) proposed information sharing as one of the strongest mitigating factors to addressing the bullwhip phenomenon. By information sharing, their study specifically referred to good quality information on consumption, demand and point-of-sale data. They also alluded to the alignment of supply chains, whereby replenishment was done continuously through quick responses to demand and inventory planning, where coordination between supply chain links occurred. These mitigation practices tied in with the research topic, where end-user consumption needed to be used as the trigger for flow of inventory within a supply chain. Lee et al. (2004) called for sell-

through data and information on inventory statuses at downstream links to improve channel coordination, which will over time dampen the bullwhip effect. Stavrulaki and Davis (2010) emphasised the importance of close supplier-customer relationships, where information is shared freely. They argued that the effect of these links resulted in significant cost reductions, which will also serve as countermeasures against the bullwhip effect.

Barros et al. (2013) provided a list of performance improvements, which can be achieved when information is shared freely across supply chains. Inventory and lead time reduction topped their list. Other improvements were capacity utilisation, cost savings through a reduction of warehousing and transportation expenses as well as increased service levels. They proposed centralised inventory control systems and the use of electronic data interchange (EDI) as possible solutions.

2.5 Make to Stock (MTS) versus Make to Order (MTO)

The interventional cardiology medical device industry is of such a nature that inventory needs to be available in the catheterisation laboratory as and when the cardiologist asks for it. This means that inventory needs to be manufactured on a make-to-stock basis, as downstream links are not willing to wait. If the cardiologist was in a position to communicate a demand signal to the supplier a couple of days in advance, it would not have been necessary to carry any inventory at the catheterisation laboratory and a make-to-order supply chain policy would have been ideal, where inventory would have been kept to a minimum along with little chances of obsolescence.

A growing trend in the market currently is hybrid push-pull controlled systems, where inventory is partially manufactured into a semi-finished form. As soon as a pull signal is received, the remaining customisation processes are completed and shipped to the customer (Kim, Fowler, Shunk, & Pfund, 2012; Mahapatra et al., 2012). This strategy will not be feasible in the interventional cardiology medical device industry due to the downstream links' unwillingness or inability to wait.

Kim et al. (2012) and Stavrulaki and Davis (2010) identified four distinct supply chain structures. They were make-to-stock (MTS), make-to-order (MTO), design-to-order (DTO) and assemble-to-order (ATO). They explained that each of the supply chain structures should match the product's demand characteristics. They argued that supply chain processes that cross organisational boundaries and link manufacturing

companies, suppliers, distributors and customers will result in a sustainable competitive advantage to all. Niezen and Weller (2006) supported that sentiment. They also argued that opposed to having transactional supply chain processes, these processes have now evolved to become significantly more strategic.

The research that has been conducted, sought to understand the level of agility and leanness required to service the interventional cardiology medical devices industry well. In a make-to-stock situation, where inventory is managed through consignment stock management, the supplier needs to guard against pushing product onto downstream supply chain links. Schragenheim and Burkhard (2007) claimed that make-to-stock is the best solution where production and delivery lead times are longer than the customer's willingness to wait. This willingness to wait was called the client's tolerance time. Kim et al. (2012) called this willingness of a customer to wait the Delivery Lead Time (DLT).

The Theory of Constraints (TOC) principle promotes shortened replenishment times. If these principles are followed closely, the level of inventory will automatically drop, as the supply chain will have the ability to rapidly respond to customer demand. Therefore, opposed to a product push, dynamic buffers need to be calculated based on end-user consumption in combination with the stock on hand numbers at the customer's location. Additional inventory at other warehouses and storage locations within the same chain will also need to be added. After these buffers have been sized, product should only flow when there is consumption from the buffers and for no other reason (Schragenheim & Burkhard, 2007). The objective of TOC in this environment is not to only have stock on the shelf, but to have high availability of stock. Having the wrong stock on the shelf is not helpful, having inventory available, which end-users need or want is helpful, that is called make-to-availability.

2.6 Vendor Managed Inventory (VMI) and Consignment Stock Management

Vendor managed inventory is a practice where suppliers are responsible for inventory levels at the downstream links' point-of-sale (POS) locations. Here, the supplier has to determine order sizes and timing of inventory shipments to the downstream links. The supplier therefore makes the replenishment decisions and downstream links do not have to carry the burden of managing inventory. Cox and Schleier (2010) described VMI as a win-lose kind of relationship where the supplier has to comply with whatever the customer tells him to do.

Inventory buffers are mainly calculated based on point-of-sale inventory data. In theory, the benefits of vendor management inventory systems should be an increase in stock turns at the downstream link as well as a reduction in stock outs (Battini et al., 2013). Nicholson, Vakharia and Erenguc (2004) claimed that outsourcing of inventory decisions in the healthcare industry has become current practice, especially in the form of consignment stock solutions.

Consignment stock practices are very similar to those of vendor managed inventory, the difference, however, is that with consignment stock management the inventory only passes ownership and risk after stock items have been consumed at the customer's location. Only at the point of consumption will the customer process payment to the vendor or in line with agreed upon payment terms. Vendor managed inventory can also be applicable where the vendor manages the customer's inventory on the customer's behalf, even after payment has been made to the vendor and inventory is already present on the customer's shelf. Schragenheim and Burkhard (2007) looked at vendor managed inventory from a theory of constraints perspective and suggested that inventory buffer sizes have to be calculated and agreed upon in advance. Replenishment to these buffers only need to take place as and when consumption occurs from those buffers. If replenishment is done on a regular basis and only after consumption has taken place, buffer sizes can be small. By actively abiding by these principles, inventory levels will be kept to a minimum.

Nag et al. (2014) argued that medical manufacturers need to carry the risk of high inventory levels due to the fact that hospitals are not willing to keep significant levels of inventory at their locations. In fact, many hospitals do not even want to carry inventory of certain products on their books and only remunerate suppliers as and when products are used. They further suggested that medical suppliers should move towards consignment stock management and / or vendor managed inventory solutions. Doing so, the system will be characterised as a system that will push inventory downstream into the supply chain. This is good evidence that suppliers need to look for innovative solutions that will safeguard their own interests and in the process, will keep inventory levels down and ultimately costs at acceptable levels.

2.7 Whole System versus Local Optimisation Concepts

Whole systems thinking has to be considered should supply chain professionals attempt to reduce waste within the medical supply chain or any other supply chain for that matter. Barros et al. (2013) agreed to this in that the various systems need to be viewed as a whole should these supply chains attempt to achieve superior performance. These supply chains should, therefore, be managed in a holistic manner as opposed to each supply chain link trying to look after its own interests. A local optimisation mind-set is perceived as pursuing one's own self-interest. Self-interest disregards system-wide profits and mainly focuses on individual gain. Barros et al. (2013) proposed the exchange of information and coordination between supply chain links as solutions to the phenomenon of self-interest. Alignment policies between business strategies and practices are needed. It is further proclaimed that local efficiencies need to be abolished because they are perceived as being inefficient. It was suggested that systems should rather endeavour to optimise the system as a whole (Goldratt, Cox & Whitford, 1992; Goldratt, 1994; Goldratt, 2009).

2.8 Theory of Constraints Thinking Process

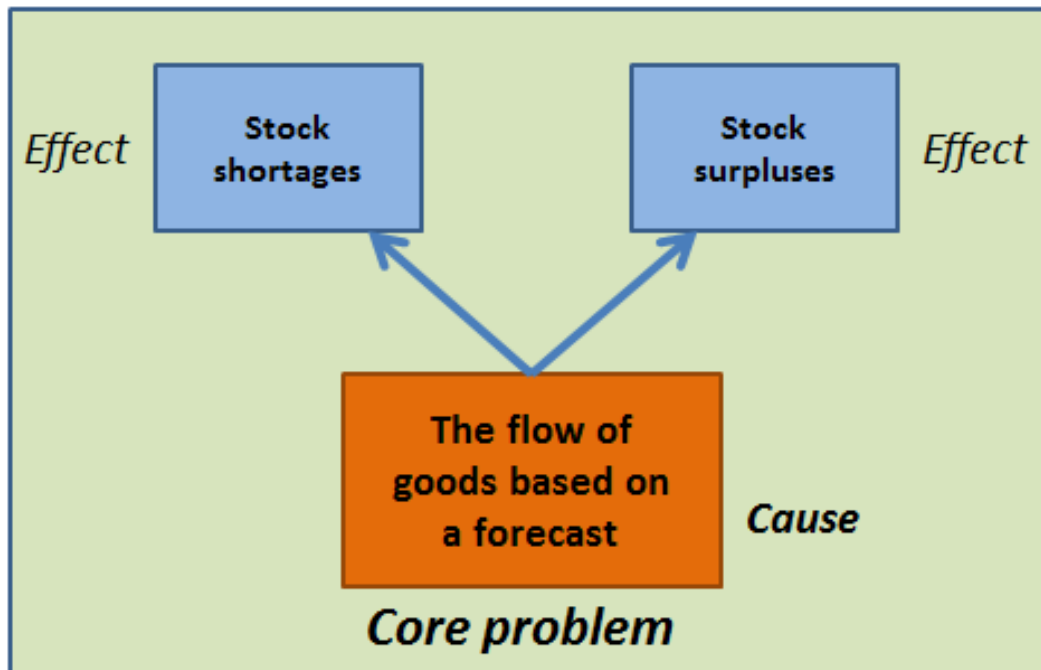
In order to understand the current reality better as well as cause-and-affect logic, theory of constraints (TOC) recommended a logical thinking process (TP). Tulasi, Rao and Tirupati (2012, p.337) described this thinking process as follows: "The thinking process consists of "trees" or logic diagrams that provide a road map for change, by addressing the three basic questions of What to change, To what to change, and How to cause the change. The thinking processes focus on the factors that are currently preventing the system from achieving its goals." The overall goal is to identify effects / problems / symptoms and to develop the necessary thinking to recognise what the root cause is in order to understand reality a lot better and to ultimately resolve problems. Cox and Schleier (2010, p.730) argued that "the better our capability to uncover and understand the actual cause-and-effect relationships that exist today, or that we intend to put into place tomorrow, the better our capability to improve".

2.8.1 Current Reality Tree (CRT)

In any environment, there will in all probability be elements that a TOC practitioner will not be happy with. These existing conditions are realities. An example applicable to inventory management in the interventional cardiology industry might be that hospitals struggle with out-of-stock situations or there might be an oversupply of stock in the market. These realities can be summarised as surpluses and shortages. Those “issues” within the current reality tree (CRT) framework are described as current realities or effects (Tulasi et al., 2012). Current reality trees can be used to describe the present (Blackstone, 2001). The CRT is a logic structure that helps to depict a certain reality within a particular system like inventory management in the interventional cardiology industry. Undesirable effects like surpluses and shortages, better known as problems, are also called symptoms. The overall aim will be to eradicate all the symptoms by addressing the core problem or cause, therefore the term “cause-and-effect” network. The purpose of the current reality tree is to find the core problem and to figure out what the cause of these undesirable effects might be (Tulasi et al., 2012). Cox and Schleier (2010) agreed, saying that a core problem is the common cause for many undesirable effects and the answer to the question, “what to change”.

Figure 2.1 is a current reality tree outlining a cause with effects, where the undesirable effects are surpluses and shortages. If replenishment is done and buffers are built based on forecasts, the effect is surpluses and shortages. The logic behind this is that flow based on forecasts is generally unreliable and that flow should rather be analysed and triggered based on real-time consumption patterns. An example will be where stock is produced and moved to downstream links in the supply chain, only to realise that the reality differs from the forecast and this premature flow caused an unnecessary build-up of stock downstream. The aim is to break the assumptions that caused the effects. One assumption might be that a certain amount of inventory has to be available on the shelf (based on a forecast) in the catheterisation laboratory long before demand. And because demand is significantly different to the forecast, the effect is that incorrect quantities of inventory will be present in the system.

Figure 2.1: Current Reality Tree



2.8.2 Evaporating Clouds (EC)

After the effects or symptoms have been identified, solutions need to be found to remove or rectify those problems. One should think of these solutions as answers to burst these evaporating clouds and ultimately remove the problems. The aim is to find assumptions that can be broken in order to vaporise the problem (Tulasi et al., 2012). Cox and Schleier (2010, p.748) asked two questions: "What is the conflict that blocks the core problem from being resolved? What will eliminate the conflict and open the gate to the future?"

2.9 Buffer Management

Hurley (1996) argued that buffers along the supply chain protect downstream links in need of inventory from supply fluctuations coming from vendors. These supply oscillations can be caused by a variety of reasons. One such reason is variations in processing time due to manufacturing equipment breakdowns further up in the supply chain. Another reason is variations in manufacturing processing times. Nag et al. (2014) confirmed that supply chain agility can be seen as a firm's competitive advantage and emphasised the fact that a supply chain needs to be market

responsive. They do, however, admit that agile supply chains need to hold inventory buffers in order to hedge against the risks of supply disruptions. Another dimension was added to buffer management, where it was argued that buffers do not only safeguard supply chain links against supply variations, but also against variable demand coming from end-users and other downstream links (Nag et al., 2014; Schragenheim & Burkhard, 2007).

Therefore, they argued that daily consumption as well as stock-on-hand numbers needed to be taken into consideration when sizing buffers along the supply chain. They also promoted dynamic buffers as opposed to static buffers that automatically adjust to changing customer demand over time. Inventory simulation software like Symphony, designed by Inherent Simplicity, helped to calculate and simulate these buffers, based on changing demand and supply parameters. This methodology ensured that buffers were adjusted not only upwards in the specific supply chain, but also downwards depending on fluctuations in demand. Janse van Rensburg (2014) was confident that dynamic buffer management solutions will have an immediate effect on improving profitability within supply chains.

In order to operate in a lean inventory environment, strategic inventory buffers – also called dynamic buffers – need to be present to avoid overstock as well as stock-out situations (Janse van Rensburg, 2014). Hurley (1996) stated that properly sized buffers are required in the various locations along the supply chain in order to protect the throughput rate. In this study, throughput rate can be defined as the profit margin, meaning sales revenue minus the cost of goods sold. Without the presence of a throughput rate, no organisation can support sustainable growth into the future, as the goal of any organisation is to make profit now and also in the future. If one cannot generate a revenue stream, one cannot generate profit (Goldratt et al., 1992).

Kumar et al. (2013, p. 87) provided a thorough explanation of a pull replenishment system within a production framework, which is however also applicable to normal principles of flow: “In a pull / replenishment system, a very small strategic level of inventory is built and maintained in bins at selected points in the production process. When a downstream customer takes away specific items, they are replenished. If a customer does not use an item, it sits in a bin, but is not replenished. When the strategic inventory is depleted, the downstream customer uses a simple card or “Kanban” as a signal to order the upstream supplier to refill the bin with a specific number of parts or send back a card with detailed information regarding the part and its location”. In a supply chain, where the only concern is inventory moving from a central

warehouse to the point of consumption, the above-mentioned Kanban card can be replaced by a simple consumption signal sent from the location, where consumption has taken place, to the supplier responsible to arrange for replenishment to take place.

Kumar et al. (2013) named this a consumption-driven replenishment system, which has proved its application across supplier and distribution network tiers. They argued that this system is a popular alternative compared to push and traditional material requirements planning (MRP) systems, which are strongly dependent on forecasts as signals for material flow. These signals generally result in overstock situations and often lower customer service levels because inventory is not available in the right locations for consumption to take place, also called stock-outs. Stock-outs are expensive and cause many disruptions within supply chains. Kanban-driven supply chains ensure that re-orders only occur when actual consumption has taken place at the point of use. If the inventory buffers are sized correctly and are combined with swift replenishment mechanisms, very little stock-outs will occur.

2.10 Supply Chain Simulation

Chin et al. (2012) suggested the use of a simulation exercise to diagnose a supply chain's performance. Goldratt and Goldratt (2005) cited in Chin et al. (2012) suggested that the following aspects need to be true within supply chains, which are true to theory of constraints principles:

1. Inventory replenishment needs to be driven by actual consumption.
2. The majority of inventory needs to be stored at the factory / regional warehouse.
3. Shipments to end-users need to occur daily or as often as possible.
4. Buffer sizing is based on both time and variability to replenish.
5. Buffer sizes depend on variability in demand and supply.

2.11 Limitations

Eliyahu Goldratt's views are often seen as being controversial and might not be perceived by academia as generally accepted in the field. Goldratt's views, therefore, were compared with other theories within the same area of study.

2.12 Conclusion

In this chapter, all elements related to the research topic were discussed. Theories and practices related to the various research questions were also considered and explored. A brief description of supply chain management and the effectiveness of information sharing were followed by relevant supply chain concepts applicable to the study.

Pull and push policies, various forms of waste as well as safety stock and dynamic buffer management concepts were discussed at length. Further concepts related to the research topic were also included, they were: Lean practices; The Bullwhip effect; Make-to-Stock and Make-to-Order; Vendor Managed Inventory and Consignment Stock Management; Whole system versus Local Optimisation concepts.

The following chapter will introduce the research questions.

CHAPTER 3: RESEARCH QUESTIONS

The scope of this research is to investigate the various triggers for flow that exist within the interventional cardiology medical devices industry and also to understand the business model and operating environment in which supply companies and hospitals operate in this industry. The ultimate aim is to understand the various triggers for flow of inventory.

Four main and two sub-research questions were developed. The research questions are as follows:

Research Question 1: Is end-user consumption used as the trigger for flow of interventional cardiology medical devices?

Research Question 1A: Is end-user consumption used to build the various buffers in the cath lab?

Research Question 1B: Is end-user consumption used as the trigger for flow after the product is used in the cath lab procedure?

Research Question 2: Is consignment stock management best practice when managing inventory of interventional cardiology medical devices at hospitals?

Research Question 3: Is useful information effectively shared between hospitals and suppliers within the interventional cardiology medical devices industry?

Research Question 4: Is waste present within the supply chain of interventional cardiology medical devices?

CHAPTER 4: RESEARCH METHODOLOGY

4.1 Introduction

The purpose of this chapter was to provide details of the various research aspects that were used to best answer the research questions posed in the previous chapter. These chosen aspects had to be defended. The chapter concluded with ethical considerations as well as potential research limitations.

4.2 Research Methodology

This research required a deep dive into the world of interventional cardiology to establish what the interventional cardiology medical device industry's supply chain in South Africa looks like. Because of the vast complexities typical to this industry, combined with an unfamiliar element, an exploratory study had to be pursued (Saunders & Lewis, 2012). A qualitative study was subsequently conducted, which was suitable for this particular study because of the relatively small population of suppliers serving the interventional cardiology medical device industry in South Africa. Qualitative studies are suitable when a researcher attempts to interpret a variety of phenomena through having detailed discussions through interviews with experts in the industry, something which descriptive strategies will not be able to provide (Leedy & Ormrod, 2005). Marshall and Rossman (2014) confirmed that qualitative research is ideal where researchers demand practical answers to complex questions.

Given the fact that little information existed on how interventional cardiology medical devices' supply chains operate, a deep exploratory research approach had to be conducted to find out more about the studied area. The exploratory approach assisted in clarifying general topics that were unknown and supported the study to gain further insights, which helped inform the research design further (Drupsteen, van der Vaart, & Pieter van Donk, 2013; Saunders & Lewis, 2012). Qualitative research methods help researchers to delve deeper through asking new questions. Answers to these questions help to gain important new insights (Saunders & Lewis, 2012).

According to Yin (2013), an enquiring mind is a prerequisite during the data collection process. A substantial amount of time was spent on the structure of the questionnaires as well as the way in which the interview process had to be approached. There are

commonly required skills needed to succeed in case study design as set out by Yin (2013). These required skills are:

- Asking good questions alone is not good enough, interview answers need to be interpreted correctly.
- Own ideologies must be put aside and interview answers need to be carefully listened to.
- Newly encountered situations and topics have to be seen as opportunities, not as threats. Flexibility and adaptability therefore have to be employed throughout the various interviews.
- A well-founded understanding of the issues being studied assists a great deal. Such an understanding helps to digest the information into manageable proportions.
- Biases and preconceived notions have to be guarded against. Information that contradicts the data derived from theory is therefore greeted with an open mind.

A high level of energy is applied to each interview, which led to the depletion of analytical energy. Emotional and mental exhaustion at the end of each interview is seen as a good sign (Yin, 2013). This exhaustion serves as evidence that good questions are asked throughout the data collection process and that the openness to opportunities leads to new insights.

The study furthermore contained explanatory elements as there was an attempt to find relationships between variables and to understand why certain phenomena were emerging. It was believed that most qualitative studies will benefit from a few elements of quantitative processing of data (Saunders & Lewis, 2012). Yin (2013) suggested that the case study methodology is considered best when researchers attempt to have “how” and “why” questions answered. He further urged that research questions, objectives and procedures had to be compiled thoughtfully and followed throughout the research project. The key aim of an exploratory case study was to identify certain phenomena in search of patterns arising from these case studies. The objective was to draw a single set of “cross-case” conclusions through covering multiple cases. In this situation, case study designs overlapped with other forms of research methods, whereby an empirical topic was investigated by following an array of predefined procedures.

4.3 Research Design

Eight case studies were built. The majority of the four supply companies, where data was gathered from, were amongst the most prominent supply companies in the industry and market leaders in the field of interventional cardiology medical devices. These companies combined hold more than eighty percent of the total market currently served in South Africa. All four companies are also big players in the global market and have a large international footprint.

Additional to the supply company interviews, experts working at four different hospitals were interviewed. These experts included hospital pharmacy managers, inventory managers, a stock controller and a theatre nurse. All four participating hospitals were part of one of South Africa's major private hospital groups.

A multiple-case study approach was pursued, whereby leading suppliers within the industry were interviewed as well as the end-users of interventional cardiology medical devices in the form of hospitals within the same supply chain. According to Gerring (2006), this form of research is called a comparative method case study design. Yin (2013) went by the term multiple-case studies; he also stated that single- and multiple-case designs are seen as variants in the same methodological framework.

In order to ensure robustness, a multiple-case design was conducted as evidence from multiple cases is generally considered to be more compelling in comparison to single-case designs (Yin, 2013). Due to the narrow focus of the research topic, a single-case design arguably would not have generated the desired amount of evidence and information on the topic. There was, however, an awareness of the pressure, which multiple-case designs would have put on available resources, time constraints were of particular concern. The logic underlying the use of multiple-case studies was to find similar and/or contrasting results. Small supply companies as well as goliaths in the industry were used in this study; the aim was to have a sample representative of the entire universe of interventional cardiology medical devices.

4.4 Population

According to Saunders and Lewis (2012), it often happens that all members of a certain population cannot be used in a research study; most of the time it is just not feasible because of members being diffused across demographic areas. In this research, all suppliers and users of interventional cardiology medical devices in South Africa formed part of the total population. The complete set of supply companies as well as all hospitals and clinics with catheterisation laboratories are called the sampling frame. The sample had to be narrowed down, seen that collecting data from the whole population of suppliers and catheterisation laboratories would not have been practicable. Case studies are time-consuming to complete and time limits set to have the research project completed also necessitated a smaller sample size.

4.5 Sampling Method and Size

Due to the vast size of the population and the unlikelihood of identifying each and every member of the population, it was fitting to use a non-probability sampling technique. Probability sampling could not have been used, therefore, seeing that a sampling frame of the whole population was not available (Saunders & Lewis, 2012). Probability sampling is largely inappropriate for qualitative research as elements within the population are chosen at random and have a known probability of selection, a technique that would not have suited this study (Ritchie, Lewis, Nicholls & Ormston, 2013).

Marshall and Rossman (2014) pointed out the importance of well-developed sampling decisions and that these decisions are crucial for any study's soundness. Each of the non-probability sampling techniques was carefully evaluated and purposive sampling was chosen as the best technique for the proposed study.

According to Saunders and Lewis (2012), this technique is most frequently used by researchers following non-probability sampling techniques and is ideal when selecting small samples while collecting qualitative data. Ritchie et al. (2013, p.78) confirmed that purposive sampling was fitting, where particular features or characteristics were explored, enabling "detailed exploration and understanding of the central themes and puzzles that the researcher wishes to study". Saunders and Lewis (2012) confirmed that purposive sampling should be used where the researcher has to use his or her own judgement to choose those participants best suited to answer the research

questions and meeting the objectives of the study. Careful choices had to be made in order to derive at logical generalisations from the interview data collected.

Four supply companies of interventional cardiology medical devices were chosen to form part of this study. All four companies were members of the South African Medical Device Industry Association, also known as SAMED. SAMED is an industry association with an annual income of R4 million generated through subscription fees. These four members combined, owned more than eighty percent of the market and were therefore representative of the whole market of interventional cardiology medical devices in South Africa. The majority of the supply companies, where data was gathered from, were amongst the most prominent supply companies in the industry and market leaders in this field of interventional cardiology medical devices in South Africa. All four companies are sizeable players in the global market and have a large international footprint.

Additional to the supply company interviews, experts working at hospitals dealing directly with the use and stock management of interventional cardiology medical devices were interviewed. These experts included hospital pharmacy managers, inventory managers, a stock controller and a scrub sister, all currently employed at four different hospitals. All four participating hospitals were part of one of South Africa's major private hospital groups. Access to these experts was restricted and was found to be challenging. Seen that private hospital operations in South Africa are relatively uniform, only one private hospital group was focused on and generalisations were drawn from the findings. This particular private hospital group, however, was studied in detail, meeting with eight experts within the same group.

4.6 Unit of Analysis

The unit of analysis was the trigger for flow. Yin (2013) described the unit of analysis as the fundamental problem of defining what the “case” is all about. The unit of analysis was firmly cemented in the research topic and was also clearly defined in the research and interview questions.

4.7 Data Gathering Process

Face-to-face interviews were conducted. Interviews are one of the generally accepted data collection techniques when conducting case study research. The data collection process was mainly done through asking unstructured as well as semi-structured questions. It was found that unstructured questions served as a useful tool in order to explore the environment in which the participants operated. This was an effective tool particularly during the initial interviews as it served to shed light on the various topics laid out in the planning process (Saunders & Lewis, 2012).

Participants were given a set of themes to talk about and more structured questions were asked thereafter. A different set of questions were developed for supply companies and hospitals (refer to Appendices 1 and 2). Unstructured interview questions assisted in exploring general topics, but prompts were used to keep the conversations focused. Fixed prompts were themes that had to be covered where floating prompts were used to explore information and topics mentioned by the participants. An unstructured interview process is described as: “you want your participants to talk openly and widely about the topic with as little direction from you as interviewer as possible. For this reason, they are sometimes called non-directive interviews” (Saunders & Lewis, 2012, p.152).

In depth interviews were conducted with sixteen experts in the industry. From the nine interviews conducted, four were done one-on-one; the other five were conducted in group format. There were a total of sixteen participants. Each interview lasted for about two and a half hours. An invitation to spend a morning in theatre was extended by one of the hospitals. An interventional cardiologist was observed whilst busy with a procedure; observational research techniques were used to collect information. The experts working for the supply companies were mainly executives, divisional managers, product managers, planning managers as well as heads of supply chain operations. Hospital staff members were pharmacy managers, inventory managers, a stock controller and a scrub sister.

Richness of data was the aim in an endeavour to identify assumptions made in the industry. Another aim was to gather information, which firstly would have answered the research questions and secondly, had to concur or build on the theories and practices identified in the literature review.

All interviews were done at the participants’ respective offices. Hospital staff members were also interviewed at their offices based at the various hospitals. A lot of depth as

well as non-verbal information emerged from these interviews. For the supply companies, each office had a unique look and feel which tied in with their success in the market. Some locations were more rigid and straight forward, whereas other offices boasted high technology and innovation. The majority of participants were relaxed and knowledgeable in their respective fields of expertise. Conducting interviews at the hospitals were interesting. Offices were a lot smaller and the layouts were a lot more basic. The typical smells and sounds of hospital life were pertinent. Process flow is very important in hospitals and rightfully so, seen that preservation of human life is their priority.

4.8 Data Analysis

4.8.1 Interviews

Qualitative analysis software was used to analyse and code the collected interview data. ATLAS.ti software offered such a solution. ATLAS.ti is a computer-aided data analysis software package designed for qualitative research. The software helped to identify different themes from the study and to organise the findings logically.

Interviews were recorded and transcribed. Interview notes were analysed thoroughly. The aim was to find key themes and rich data transpiring from the interview data. In order to identify patterns within the interview data, an inductive approach was used. An inductive approach identifies patterns throughout the analysis process. The data was coded and different themes and topics were identified and categorised accordingly (refer to Appendix 3). These themes showed rigour in terms of the quality of the research and that data saturation was reached. The overarching aim was to find meaning in the data in order to answer the study's research questions (Leedy & Ormrod, 2005).

4.8.2 Simulation

The primary data collected in the industry was analysed, using a software package called Symphony. The software helped to analyse cause and effect relationships, something that qualitative software like ATLAS.ti would not have been able to do.

The simulation helped to understand the current reality better as to what is happening in this specific supply chain. In order to understand the current reality, it was necessary to identify various effects / problems present within the interventional cardiology supply chain and to understand what the core problem was that caused those symptoms.

4.8.2.1 The simulation exercise

A supply chain simulation exercise was furthermore conducted that used primary data as an input. The required data was supplied by one of the supply companies. Specific reports were run on a daily basis over a four month period, which took up a significant amount of time. Data, thereafter, had to be processed and categorised in the correct format in order to ensure data integrity and realistic results. The data that was required will be discussed in more detail below.

4.8.2.2 Simulation software

The processed data was fed into a software simulator called Symphony. Symphony software offers theory of constraints solutions to the supply chain operations of organisations and consists of a suite of applications licenced in South Africa under an agent called Cargo Solutions. Cargo Solutions is a division of Cargo Carriers, a company listed on the Johannesburg stock exchange. The software package Cargo Solutions offer to their clients is called Symphony Supply Chain Buffer Management Software, developed by Inherent Simplicity Ltd. Symphony is a suite of applications with a buffer management module operating at its core. Symphony can be interfaced easily with a company's ERP system like SAP, Syspro, Accpac or Oracle. Symphony is simple to use and easy to deploy. The developers believed that dynamic buffer management of inventory in supply chains improves profitability and this theory was put to the test in this study, using primary data found within the interventional cardiology medical device industry (Janse van Rensburg, 2014).

4.8.2.3 Assumptions made

Assumptions in terms of the data used had to be made as only one supply company's data was used. The goal was, therefore, to be able to draw generalisations across the industry to ensure that the results found were representative of the interventional cardiology industry. The interview data was therefore pivotal to help understand each supply company's supply chain and the challenges they faced. It was also important to understand whether all supply companies operated more or less under the same circumstances and were governed by the same rules set by the private and public health industry in South Africa. Products, stocking locations and pricing data used in the simulation exercise had to be representative of the interventional cardiology industry in South Africa.

4.8.2.4 Aim of the simulation

The simulation was used to serve as a process of triangulation to confirm whether the interview data was aligned with the findings from the simulation exercise. It was done to test whether the supply company data concurred with the hospital staff members' data, ensuring robustness of the findings (Saunders & Lewis, 2012). Another aim of the simulation exercise was to compare the current reality (status quo) present within the industry with that of a simulated state.

Furthermore, the goal was to shed light on certain areas to help the supply companies identify possible improvements. Stock-outs in any industry equate to lost revenues, but not only that. In most instances, stock-outs prompt customers to look elsewhere for competitor products, as they are not willing or able to wait. If a stock-out situation continues, suppliers might lose customers for life. In the interventional cardiology medical device industry, suppliers only get paid when customers consume their products on consignment. The simulation programme has an algorithm that allowed for an actual monetary value to be put on lost sales due to stock-outs. If products are overstocked and not moving, they are taking up space in the catheterisation laboratories without generating any return for the supplier. Apart from stock items eventually expiring and coming off the bottom line, suppliers do not want their capital tied up in working capital that is locked up in unsold inventory (Janse van Rensburg, 2014).

Theory of constraints (TOC) practices believed that supply chain management is a field that should receive much more attention. The developers of the software, Inherent

Simplicity Ltd, shared the same sentiment. The reason for their statement was that efficient inventory control will assist in avoiding stock-out situations as well as overstocking. TOC described this as maximising flow, minimising lead times and achieving a reduction in inventory levels. If those areas can be improved, immediate results can be achieved both on the income statement as well as the balance sheet.

4.8.2.5 Data requirements

Symphony supply chain buffer management software needed a specific set of variables that had to be provided by the supply company. These variables were needed to generate realistic results. They were:

- Daily sales data at each stocking location / catheterisation lab – preferably for the past year
- Daily stock-on-hand data at each cath lab – preferably for the past year
- Daily stock-on-hand data at each local warehouse / stocking location
- Stock location codes and descriptions
- Stock keeping unit (SKU) codes and names
- Lead times – from the international suppliers as well as the time it takes to deliver to the customer after receiving a pull signal from the hospital
- Unit of measure per SKU
- Minimum order quantities per SKU
- Cost price per SKU
- Selling price per SKU.

4.8.2.6 The logic behind the simulation exercise

The simulation software works best under conditions of daily replenishment. Weekly or monthly replenishment cycles are also feasible, but smaller batch sizes more often are the ideal. These requirements are consistent with TOC principles of flow.

The simulation could have been done at the local distribution centre level, but due to the complexities of the interventional cardiology industry, the simulation was done at the catheterisation laboratory level, as each cath lab carries its own amount of buffer stock that has to be ready for consumption should the demand arise. At the time of the study, there were 55 cath labs spread across South Africa. Distribution centres can be

simulated by Symphony, but for the purpose of this study, these were excluded as the majority of sales in the interventional cardiology industry occur at cath lab level. It was assumed that the distribution centre had unlimited inventory to service the market. It was consequently decided to simulate two scenarios, which replenished to buffers, one with a lead time to the cath labs of 2 days, and the other scenario with a 15-day lead time. It is important to note that these days were calendar days and not working days.

The buffers based on the 2- and 15-day lead time were then calculated based on total daily consumption and the other variables. Expected results included the following:

- A buffer reduction at certain cath labs as well as a possible buffer increase at others
- Inventory turns should improve holistically; and inventory – across the board – should decrease by around 50%
- Improvement in stock-out days, which will have an impact on revenues
- Inventory will be reduced if availability can be kept the same or improved.

The simulation, therefore, provided results demonstrating:

- **Inventory** – A possible percentage reduction in inventory
- **Availability** – A possible percentage reduction in stock-out days
- **Sales** – A possible percentage decrease in lost throughput, an increase in inventory turns and ultimately an increase in return on investment (ROI).

Companies will then be left with the choice between whether they would like to remain on a forecast-based supply chain system or would rather switch to a replenishment-based supply chain system which Symphony can provide.

Symphony looked at the following simulation specifications:

- a) Total number of stock locations – the total amount of cath labs used for the simulation
- b) Total number of stock keeping units (SKUs) – the total amount of SKUs used for the simulation
- c) Total number of SKU locations – the total occurrence of SKUs at each stock location. For example, if all SKUs were found at each stock location, this would have been a multiple between a) and b) in the above

- d) Simulation period – the period in calendar days used for the simulation.

Symphony looked at the following TOC indicators to establish whether improvements could be made:

Note:

- TVC stands for Truly Variable Cost. In the interventional cardiology supply industry, TVC is the cost price of goods, also known as the unit cost of goods
- The TOC definition of throughput is defined as the selling price of an item minus its cost price, thus the selling price minus TVC.

- a) Average inventory value

Calculation: $\Sigma (\text{Average daily inventory} * \text{TVC})$

- b) Closing inventory value

Calculation: $\Sigma (\text{Closing inventory} * \text{TVC})$

- c) Stock out days

Calculation: Overall number of days stocked out, per SKU

- d) Lost throughput days (TVD / throughput value days)

Calculation: $\Sigma (\text{Stocked out SKUs} * \text{Average consumption of SKU} * \text{SKU throughput})$

- e) Inventory Turns (ITR)

Calculation: $\Sigma (\text{TVC} * \text{Consumption}) / (\text{Average inventory value})$

- f) Return on investment (ROI)

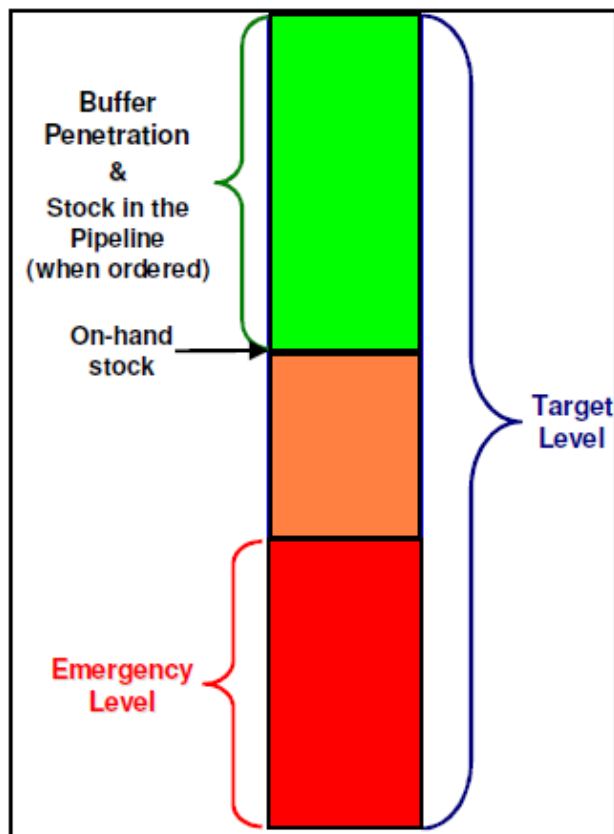
Calculation: $\Sigma (\text{Throughput} * \text{Consumption}) / (\text{Average inventory value})$

Calculating the buffer

Taking the above into consideration, Symphony will apply dynamic buffer management (buffer sizing) to each SKU at each stock location, prompting the user to increase or decrease stock levels. The system will, therefore, prompt the user to immediately realign; this is driven by end-user consumption. The main purpose of dynamic buffer management (DBM) is to assure availability while avoiding unnecessary overstocking. The stock buffer size is also called the maximum target for replenishment (Cox III & Schleier, 2010).

Symphony uses a “traffic light” / priority system illustration to describe an item’s buffer structure. Figure 4.1 explains it in more detail.

Figure 4.1: Buffer Structure



Source: Schragenheim & Burkhard (2009)

The goal is to have the on-hand stock available for sales falling within the orange (middle) zone, thus not too full and also not too empty. The ideal is to alternate between the green and orange zones. When an item is in the orange zone, more stock will most probably already be in transit to arrive within a set lead time. The DBM mechanism is designed in such a way that the inventory manager will be alerted when the buffer size is too large or too small (Cox III & Schleier, 2010).

When it happens that an item finds itself too often in the red zone, there could be a variety of reasons with an increase in demand growth being one of them. Other reasons for being in too much of a red condition are: the supply rate has decreased, the initial buffer size was too low or demand fluctuates severely (Cox III & Schleier, 2010). If this continues, Symphony will adapt and calculate a higher target level. The general guideline is to increase the buffer level by 33 percent. Being in the red zone might lead to stock-outs and lost sales. All suggested increases coming from the red

zone need to be expedited to avoid lost sales. Stock-outs are referred to as being in the black zone.

When an item is too often in the green zone, it is an indication that demand for the specific item has decreased and is most probably overstocked. The company is carrying stock they do not need. This means that the stock buffer level is set too high for current demand and this might be an indication that competitors have entered the market or sales representatives are not marketing their products well enough to doctors and hospital staff members. If this continues, Symphony will adapt and calculate a lower target level for that item. The basic guideline for needed action when remaining in the green zone too long is to decrease the buffer size by 33 percent (Cox III & Schleier, 2010).

Looking at the above figure, DBM works on two simple principles:

1. When the buffer size is too high (where there is too much green), the buffer size can be reduced and stock levels need to be brought down
2. When the buffer is too low (where there is too much red), the buffer size needs to be increased, increasing the stock levels to reduce potential stock-outs and lost sales. Symphony will trigger a purchase requisition on the user's ERP system, asking for a purchase order for additional stock.

If it is found that the interventional cardiology industry is cyclical, Symphony can be warned in advance and the necessary stock will be built in order to fulfil the seasonal increase in sales. These increments can be in the form of a percentage or a specific quantity, leaving the decision to the user. Suppliers, therefore, will have the necessary time to react. If the assumption is made that unlimited inventory is present upstream in the central warehouse and that the system can react in a day or two after pull has taken place, manual intervention will in all probability not be necessary.

In conclusion, in this environment, the Symphony distribution module will be ideal where the system firstly, will show the user what inventory needs to be delivered to the hospitals and secondly, it will prompt the user's procurement team regarding what has to be ordered from the central warehouse.

4.9 Triangulation and Data Validation

It was important to establish credibility and robustness of the research findings. The simulation, therefore, was used to serve as a process of triangulation to confirm whether the interview data was aligned with the findings from the simulation exercise. It was also done to test whether the supply company data concurred with the hospital staff members' data, ensuring robustness of the findings. Saunders and Lewis (2012, p.122) defined triangulation as "the use of two or more independent sources of data or data collection methods within one study to help ensure that the data are telling the researcher what the researcher thinks they are telling him". They also agree that should both methods' results are found to be broadly the same, it suggests that the findings are robust.

4.10 Ethical Considerations

Participation in this study was communicated as being voluntary. Prior to all interviews, participants were asked to read and sign a consent letter (Appendix 4) and all participants provided informed consent. Anonymity was promised to all participants. Names of the participants, supply companies and the hospital group therefore were not used in the research report.

Supply companies raised concerns in terms of confidentiality due to the sensitive nature of the information shared as well as the competitive nature of this industry. A confidentiality agreement had to be signed on one occasion, barring the discussion of details disclosed in the interviews with competitor firms.

4.11 Limitations

- Subjectivity and bias had to be guarded against. Potential personal bias had to be avoided to be as receptive as possible and to gain new insights and to draw new conclusions.
- SAMED members are not the entire universe of medical device companies within South Africa. Members do, however, cover the majority. The research sample, therefore, will be limited as a representation of the SAMED population; the rest of the universe was excluded.

- The study only focused on a private hospital group within the private hospital industry in South Africa. Having a catheterisation laboratory qualified a facility as a potential member of the population. The study did not focus on public hospitals, although the majority of catheterisation laboratories within South Africa are found in private hospitals.
- Triangulation does not always provide final confirmation; further detailed investigation on the topic therefore might be required (Saunders & Lewis, 2012).

CHAPTER 5: RESULTS

5.1 Introduction

This chapter presents the findings of the research. It firstly provides a short overview of the interventional cardiology medical device industry, followed by an introduction of the sample of participants who partook in the study. This is followed by multiple case studies, consisting of eight cases. Detailed results are clustered around the research questions listed in Chapter 3. Supply company results were separated from those of the hospitals in search of contrasting views between the two results. Finally, the simulation results will be presented.

5.2 Overview of the Interventional Cardiology Medical Device Industry

Cardio vascular disease is one of the top non-communicable diseases in the world. Cardio vascular disease is still classified as the second biggest killer of South Africans, second only to trauma. Angioplasty treats and prevents conditions like strokes, chest pain, heart attacks, gangrene and amputations. Interventional cardiologists mainly follow an internal procedure. They enter the vascular system through the groin or the arm. A little incision is made and an access sheet is inserted; everything works through the tubes that are inserted into the body. Younger doctors take a radical approach and work through the arm; other doctors work through the groin right into the femoral artery. Guide wires are inserted and all other instruments work over those guide wires. Doctors firstly insert a diagnostic catheter (there is a left and a right system) and then inject dye into the left side of the heart's aorta. They use different catheters to get dye into different sections of the heart. An angiogram is performed; and on the monitor, one can clearly see the vessel that has narrowed, also called an occlusion. Doctors can assess how bad the plaque is that needs to be broken down or removed before inserting a stent or a balloon. These stents and balloons are better known as interventional cardiology medical devices. Once the doctor inserts a balloon, he expands it, pre-dilates the vessel and cracks the plaque open. The cath lab team measures the lesion on the monitor and will call for a certain size stent or balloon. They remove the balloon and insert a stent. This is already mounted on a balloon, which the team expands to the correct size. Because the doctor has expanded the stent, he can now retract the balloon and leave the stent behind. He can then opt to conduct a post dilation to ensure that the stent is properly placed against the arterial

wall. If the stent is not placed correctly, this can cause complications. The cardiologist will then administer another shot with the dye to see whether the vessel is open. Procedure times differ.

Another treatment area is a condition called Chronic Total Occlusion (CTO). This is where an artery is completely occluded with perhaps only a small amount of blood flow. If the patient has had this condition for a long time, the body would have started to grow its own collateral arteries to get around the blockage. In such a condition, the medical team will insert a wire with a floppy tip. The interventional cardiologist can insert a small balloon and crack the blockage a bit, another balloon cracking it a bit more, etc. If it is completely calcified, specialised medical staff will assist and conduct a procedure called rotablation, a procedure where there is a burr at the end of the wire that drills the plaque out. Thereafter, the cardiologist will conduct the standard procedure, i.e. insert the stent, etc. Only about five cardiologists in South Africa can perform the rotablation procedure.

Interventional cardiology consists of two parts:

1. Angiography, where pictures are taken of the arteries to diagnose the problem.
2. Angioplasty will then occur only if the doctor feels there is a need to open the vessel.

A doctor will either use stents or balloons to open the affected vessels. Diagnostic guiding catheters are also placed on consignment; they are used in angiography helping with the diagnostics and also in the angioplasty procedure. Around 20 000 stents and balloons are used each year in South Africa; drug eluting stents have become extremely popular in this market.

Discovery medical aid represents around 25% of medical aid members in South Africa; this is around 2 million out of 8 million medical aid members. Rigorous processes need to be followed to get a product approved by a medical aid. There is a fair amount of what the medical aids term 'health technology assessment'. Such assessment is undertaken across the board in the medical device industry and also specifically to these products, whereby the funder has to be comfortable that the product is of a prescribed quality, that it is safe and that it provides the clinical outcomes the manufacturers claim. The same assessment process has to be followed with the

hospitals. After the hospital pharmacy has approved the products, the supply company is allowed to supply the product to the hospital. Thereafter, the supplier starts to promote it to get the doctors to use it. Shelf space in the cath lab is limited and that is becoming a huge issue for the suppliers. Prior to listing products, details such as product attributes and pricing are discussed with key opinion leaders in the industry who provide a supply company with their comments and advice.

The market environment in this industry is highly competitive. Doctors often ask for a specific size device and the technical staff will pull the product off the shelf. There are currently around 32 different drug-eluting stents on the market. In 40% of the cases, the technical staff members are the decision-makers, so the relationship with those people has to be excellent. Companies can make or break their business depending on their relationship with the technologist and the cath lab staff members. Cath lab staff members consist of the following people: the medical technologist, the cath lab sister and the radiographer. Doctors generally ask for devices by name and are very reluctant to change.

5.3 Introducing the Participants

The majority of the four supply companies that provided data were amongst the most prominent supply companies in the industry and market leaders in the field of interventional cardiology medical devices. These companies combined hold more than 80% of the total market currently served in South Africa. All four companies are also big players in the global market and have a large international footprint.

Additional to the supply company interviews, experts working at four different hospitals were interviewed. These experts included hospital pharmacy managers, inventory managers, a stock controller and a theatre nurse currently employed at these hospitals. All four participating hospitals belong to one of South Africa's major private hospital groups.

Table 5.1: Profile of participants interviewed – Supply Companies

Case	Participant	Designation	Place	Gender
A	1	Operations manager	Johannesburg	Male
	2	General Manager	Johannesburg	Male
B	1	Sales Manager	Johannesburg	Male
	2	Divisional Manager	Johannesburg	Male
C	1	Business Manager	Johannesburg	Female
	2	Supply Chain Manager	Johannesburg	Female
	3	Inventory Analyst	Johannesburg	Male
D	1	Supply Chain Manager	Johannesburg	Male

Table 5.2: Profile of participants interviewed – Hospitals

Case	Participant	Designation	Place	Gender
E	1	Pharmacy Manager	Pretoria	Female
F	1	Pharmacy Manager	Johannesburg	Female
	2	Inventory Manager	Johannesburg	Male
	3	Cath Lab Nurse	Johannesburg	Female
G	1	Pharmacy Manager	Johannesburg	Female
	2	Inventory Manager	Johannesburg	Male
H	1	Inventory Manager	Pretoria	Female
	2	Stock Controller	Pretoria	Male

5.3.1 Cases

In the results, the interviewed supply companies and hospitals will be referred to as ‘cases’. Because some of the interviews were conducted in group format, the case as well as the participant will be mentioned for example Case 1 – Participant 2. Anonymity was promised to all the participants due to the sensitive and highly competitive nature of the interventional cardiology medical device industry.

5.4 Results According to each Research Question

5.4.1 Research Question 1: Is end-user consumption used as the trigger for flow of interventional cardiology medical devices?

Research Question 1 attempts to answer the question around the triggers for flow of inventory in the interventional cardiology supply chain. The aim is to search for answers whether end-user consumption is the only trigger for flow or whether other triggers also exist.

Research question one consists of two sub-questions:

Research Question 1A: Is end-user consumption used to build the various buffers in the cath lab?

Research Question 1B: Is end-user consumption used as the trigger for flow after the product is used in the cath lab procedure?

Table 5.3 and Table 5.4 summarise the findings pertaining to Research Questions 1A and 1B from a supply company perspective.

Table 5.5 and Table 5.6 summarise the findings pertaining to Research Questions 1A and 1B from a hospital perspective.

Each set of tables is supported by direct quotes from the interviews.

Supply Companies

Table 5.3: Summarised findings on Research Question 1A from a supply company perspective

Case	Is end-user consumption used to build the various buffers in the cath lab?	Short Summary
A	No	Assumptions are made as to how much usage there is going to be. Levels are reviewed once every quarter based on past sales averages and product manager forecasts. Buffer is equal to around 4 – 6 weeks' stock. Reps sometimes keep a very small amount of stock with them.
B	No	Ideally, there should be two pieces of each item in each cath lab. Stock will remain in the cath lab based on usage history. Forecasts are based on conversations with the doctors and the level of competitor presence. Done by mutual agreement. Forecasting is like forecasting the weather, very unpredictable. You need the full range on the shelf.
C	No	Have to carry at the very least one of each size, maybe two. Whole range needs to be available on the shelf should the doctor need it. No luxury of waiting, patient is already on the table. It is a competitive advantage to have stock available sooner than the competitor. Discussion between rep and hospital stock controller. Levels calculated on stats and usage. Supply chain will monitor consumption and work out the minimum and the maximum level.
D	No	There are bucket loads of inventory on the shelf. Levels are determined by historical usage and forecasts, reps and hospitals basically get the levels they want. Hospitals want the full range, if not the full range, take all of them off the shelf. Forecasted sales based on discussion between doctor and business unit manager. Lots of stock is a marketing tool, when new products are launched, enormous amounts of stock is pushed onto the shelf.

From the feedback, it follows that buffers are mainly built on forecasts. From a TOC perspective, there is no other way to size a buffer initially. But then, in order for buffers to reflect reality, dynamic buffer management needs to be employed, which does not utilise forecasts anymore. From the interviews, assumptions were made based on historical usage and levels were in general amended quarterly. Most supply companies assume that one item of each size needs to be on the shelf. In other instances, big quantities of stock are held, serving as a marketing and awareness tool.

Table 5.4: Summarised findings on Research Question 1B from a supply company perspective

Case	Is end-user consumption used as the trigger for flow after product is used in the cath lab procedure?	Short Summary
A	Yes	Replenishment is triggered purely by customer usage. After the buffer was built, any replenishment will be based on pull signals. Invoice for the consumed item has to be accompanied by the replacement item or a back order notice. Invoice is generated and stock is replenished immediately, 20% of the time delivery is done on the same day, if not, the next day.
B	Yes	Undertake to replace the consumed item within 72 hours. The person at the supply company will invoice the consumed devices out of the consignment stock and that should be the trigger to replace. Stock is replaced, although the hospital does not ask for it. If trigger is not received and stock is not invoiced, reordering cannot take place.
C	Yes	Once the product gets used, the hospital places an order for it and the consignment is replenished. Flow is triggered on the hospital's usage coming through in the form of an order.
D	Yes	After the consumption signal is received, stock is replenished the next day before 10h00. If replenishment cannot happen the next day, hospitals want more stock on the shelf.

From the feedback, it follows that all four supply companies were unanimous that after the buffer was built, stock will only flow after consumption has taken place at the end-user / hospital level. After receiving the consumption signal, no further questions are asked and consignment is replenished.

CASE A

Case A – Participant 2: “All our movements are based on pull signals. We do not push anything. It is all customer-driven. It is all driven by usage. So on initial order [when building the initial buffer], you will make an assumption as to how much usage there is going to be and that might be the only push you are going to have, your first order. After that, any replenishment will be based on pull signals.”

Case A – Participant 1: “The invoice goes with the replacement stock, so they sign the invoice and they sign the delivery note for the new stock.”

Case A – Participant 1: “We often replace the consumed stock on the same day, provided we have replacement stock, otherwise just the invoice goes and obviously they will get a back order notice with that invoice.”

Case A – Participant 2: “We send the invoice and stock is replenished immediately.”

Case A – Participant 2: “So, what we do is we utilise our internal logistics department to take a look at the 3 and 6 month reports to see what we have sold in 3 months, what we have sold in 6 months. They take a look at what the average usage is and they work together with the product managers who take a look at the marketing, understanding what they have as to whether there are any new accounts, old accounts, are accounts declining, can we reduce levels, do we need to increase levels? And they work out what the replenishment value [buffer] will be.”

Case A – Participant 2: “I rate our outbound supply chain five out of five. Well, I am very picky about it. We do not even have delivery vehicles. We have cars with guys, so that when an order is placed they get it the same day. It is only if the order comes in late that they get it the next day.”

Case A – Participant 1: “I would say, 80% of the time possibly only the next day. But we do have same day, provided we get it [the signal] at a certain time of the morning, it will still go out that same day.”

Case A – Participant 2: “In general, we are reviewing stock levels on a quarterly basis, sometimes even monthly.”

CASE B

Case B – Participant 1: “...the only buffer will be a central warehouse and the successful rotation of stock. Ideally, there have to be two of each size in each cath lab around the country.”

Case B – Participant 2: “...we undertake to replace any stock used in the cath lab within 72 hours.”

Case B – Participant 2: “Hospitals need the invoices as quickly as possible because the hospital has to bill the patient. The person at the supply company will invoice those devices out of the consignment stock and that should be the trigger that says we now have to replace it.”

Case B – Participant 2: “...all stock with between 7 and 20 months’ shelf life will be treated as normal stock where it will stay within the cath lab, based on a usage history. When it reaches seven months to expiry, it has to be pulled out of the system and rotated to a high volume usage hospital. If stock gets very close to expiry, it is best to sell them into government at cost or even below cost. The balance will be written off.”

Case B – Participant 2: “The signal needs to get to us as the supplier as soon as possible. Why? If we do not invoice the hospital, we cannot reorder the stock. And the hospital then cannot bill and discharge the patient. Most crucial is that the system still shows stock, but the item has already been used. If the signal therefore does not get to the supplier, it directly affects our reordering cycles. Hospitals are often also rushed to get A and B done and forget to fax or e-mail the consumption through to the supplier. Monthly reconciliations are therefore crucially important. There are many variables which cause the signal to be delayed; people go on leave, off sick, etc.”

Case B – Participant 2: “...forecasting these items is like forecasting the weather. You can predict a little bit, but you need the full range. If the whole range is not

available, you are not a player. So it becomes very tricky to get this fine balance. The trick is not to overstock, but still to be flexible, finding this balance is very difficult.”

Case B – Participant 1: “...it is difficult, you do not know what sizes the doctors are going to use next and when we are talking forecasting, it is almost like a demand pull forecast if you want to call it that, we only replace what gets used, that is basically it. That is how we forecast, except where there is a special request to keep certain sizes. The buffer at this stage is one, not more like some of the larger companies.”

CASE C

Case C – Participant 1: “Once the product gets used, the hospital places an order for it and we replenish the consignment, but that does not mean the same size will be used the next time. Another size will most probably be used and that is the complexity with our business, where we have a vast amount of different sizes of stents and we have to at the very least keep one size of each at each hospital. Only around 60% of that will be used on a regular basis, but the whole range has to be available should the doctors need it.”

Case C – Participant 1: “...not sure if this will work as the patient goes in for diagnostic on the day and they say we need this and this size, they do not have the luxury of saying we can wait for another hour as the patient is already on the table. What could work is that you keep less on the shelf at the hospital and more in this local location, so that you can refill from there quicker and you do not have to keep so many items on consignment at each hospital. You can therefore reduce overall inventory, but still keep one or two of each in each hospital.”

Case C – Participant 1: “... the competitive edge is to have the products available sooner than the competitor. If you have your products available on the shelf and your competitor does not, your stent will be chosen. Cardiologists are very spoilt because everybody is trying to get the products to him sooner than the other to ensure the right product is always on the shelf at the right time. Doctors will therefore not wait, what is on the shelf they will use.”

Case C – Participant 1: “When doing stock planning, the rep will go and sit with the stock controller in the hospital, and based on past sales, they will decide what quantities they should keep on consignment in the lab. It is therefore a joint decision...”

Case C – Participant 1: “Hospitals want to keep more on the shelf because of potential issues like a delay in the signal to the supplier. Today’s cases are often only e-mailed through tomorrow. Flow is triggered on the hospital’s usage coming through in the form of an order.”

Case C – Participant 2: “We look at calculating levels and implementing levels in consignment accounts based on stats and usage. There is a typical bell curve of high movers, consumed once every six weeks and low usage products moving once every 10 months and we have to calculate outer range items. However, you need to carry them all...”

Case C – Participant 2: “...sometimes there is a push from warehouse to hospital based on rep or hospital requests...and that has been our pain. So we pushed stock based on a request, not from usage. Quarterly reviews and recently implemented par levels should help improve the process. Our lead times to the customers are really short, they are around two days to replenish from our local warehouse into outlying areas, but normally they are done overnight.”

Case C – Participant 3: “Over a period of time, supply chain will monitor consumption and work out the minimum and the maximum level that we should be keeping and update the system, which is sent off to our international supplier. So, the moment we go below our minimum, it will trigger demand from the supplying plant. Levels are therefore set up looking at the history of the various products. The stock will be replenished to maximum levels. We are currently replenished twice weekly by airfreight. The minimum and maximum levels look at the levels in our local warehouse. We have also introduced par levels, looking at our average weekly usage on consignment nationally, it will trigger total usage of a product and from there, we will calculate the minimum and maximum levels for the warehouse.”

CASE D

Case D – Participant 1: “When it comes to forecasting, what the system looks at is historical data that obviously always plays a role and then not only historical, we then also get an opportunity to forecast as well. So, the whole system is built on an algorithm that looks at historical usage, daily demand going forward, volatility and then adds the statistical forecasting based on all those factors. However, you cannot always just assume that the calculation will get it right, so there is always human interaction.

We will then go into each division to see if there are any outliers that we need to look at. We call it data cleansing.”

Case D – Participant 1: “So as the hospital uses a product, the product code, batch, quantity, expiry date, it either comes through via telephone, e-mail or the electronic system, OrderWise and we deliver the next day. So from a customer service point of view, there is a lot of emphasis placed on replacing as soon as possible and, as I say, it is the next day before 10, so that is something that I have not seen elsewhere. And it all adds up. Currently looking at consignment, I am not sure what the competitors are doing, but we have bucket loads of interventional cardiology consignment on the shelf.”

Case D – Participant 1: “For us to be able to replace the next day is critical. Otherwise, they will motivate and say if you cannot replace the next day you will replace in three days, then I want five lines on the shelf to last me until you can replace. And that just blows it out of the water because current penetration is not great when it comes to interventional cardiology. So, you will see doctors requesting and insisting on having full ranges on the shelf, which I know is the case for pretty much everyone. And you will find that the working arrangement, say you have twenty-five lines, the workhorse range will be your middle ten. You will not really see sales on the top and the bottom end. So, you end up taking the scrap cost there, but it is almost impossible to try to negotiate with them to pull that off the shelf because they will say, well, either you put this stuff on the shelf or you take all of them with. They want the whole range.”

Case D – Participant 1: “...the hospital and rep pretty much specify what they want. From a hospital point-of-view, the pharmacy manager, stock controller and doctor all determine what they need. If they want ten, then that is what we give them. It is a business requirement to replace stock regardless of whether it has expired or not and this has been the norm.”

Additional direct quotes supporting the topic can be found in Appendix 5.

Hospitals

Table 5.5: Summarised findings on Research Question 1A from a hospital perspective

Case	Is end-user consumption used to build the initial buffer in the cath lab?	Short Summary
E	No	Supply companies often use minimum and maximum levels. Plan based on monthly consumption and doctors' theatre lists.
F	No	Four or more products of each brand and size are kept on the shelf on fast moving items. Suppliers put a certain level of stock on the shelf. Some doctors use more devices than others, for them we stock up.
G	No	Pharmacy manager has a conversation with the doctor to understand what amount of stock he needs. There is not enough space in the cath lab to keep each size of each range. Stock holding is limited as far as possible. Over time the doctor's specific usage becomes predictable. Level is set by pharmacy manager and the hospital inventory team, not the rep. Two pieces of one size is a good guideline, will be adjusted as time goes by.
H	No	It is forecast based. Forecasting is difficult, but very important. Whole range has to be on the shelf, from small to big sizes – only the brand the doctor is loyal too. Some doctors use all the brands. One of each size is the rule as a minimum and will be increased until you see a trend. Companies manage their stock more closely nowadays and will remove stock that has not moved within 180 days.

From the feedback, it follows that hospitals agreed that buffers are built based on forecasts and past sales. Minimum / maximum levels trigger flow from the suppliers. There is communication between the pharmacy and the doctors, trying to establish how much stock is needed on the shelf. Stock is often built on assumptions.

Table 5.6: Summarised findings on Research Question 1B from a hospital perspective

Case	Is end-user consumption used as the trigger for flow after the product is used in the cath lab procedure?	Short Summary
E	Yes	That is generally the aim. Try to get there as close as possible. Nurse has to inform the hospital stock controller that device has been used, hospital stock controller will contact the supply company and ask for an invoice.
F	Yes	If doctor stops to use a product, supply companies will be asked to uplift their stock. When a device is used, it gets replaced automatically.
G	Yes	Consumed stock is always replenished. It makes counting easier as stock match the consignment contracts. Nurses will monitor stock levels and will order additional stock if need be.
H	Yes	The contract states, if a product is used, the supplier needs to invoice and replace. If the signal is sent through before 10h00, stock is often replaced the same day.

From the feedback, it follows that hospitals unanimously agreed that stock is always replenished after it has been used. Stock levels have to match the quantities stated in the various consignment contracts.

CASE E

Case E – Participant 1: “Supply companies know how many cases are done per month by which doctor and they will ensure sufficient quantities are available in the cath lab. They often manage their stock using minimum and maximum levels. There is also a theatre list and which doctor will do the case, they thus know which supply company’s products will be used.”

Case E – Participant 1: “...the supply company has 24 hours to send us the invoice, but most of the time it takes up to 48 hours...”

Interview question: Would you say that you only receive fresh stock as and when there was consumption within the lab? Do you believe that flow only happens after a customer pull has taken place?

Case E – Participant 1: “Yes, we try to get there as close as possible. We are meeting our own stock targets, but do have items which are overstocked, especially on the surgical side.”

CASE F

Case F – Participant 1: “...there is a lot of product in the cath lab, if the doctor stops to use a product, we will phone the reps to uplift their products, which will generally be replaced with a new technology product.”

Case F – Participant 2: “Product ranges are sometimes discontinued due the availability of new technology. The cath lab does not deplete the old range first. The old range is removed and replaced by the new range.”

Case F – Participant 2: “Doctors call for products by name. In the event of a stock-out, another supplier’s product will be used in the same size. We do, however, keep four or more of the same size on fast moving items. We are sometimes so busy that stock gets depleted. If we do, however, run out, we will contact the supply company immediately requesting more stock and sort out the paperwork later, this does not happen regularly.”

Case F – Participant 3: “...suppliers do not use reorder levels, they put a certain level of stock in place and if something is used it gets replaced automatically.”

Case F – Participant 2: “Some doctors use more devices per case than other doctors. A certain doctor, for example, can use up to five guide wires in one patient, we will therefore ensure that we stock up for that week when he is working.”

CASE G

Case G – Participant 1: “...in order to determine the amount of stock needed on consignment, I will talk to the doctor and ask him which sizes he wants on consignment. We therefore cannot keep a full range of products of each supplier on

consignment due to space constraints, it is also a liability for the hospital, seeing that we take responsibility and are contractually bound should something happen, for example, in the event of a flood or a fire. We therefore try to limit stock holding as far as possible. It also comes down to the relationship between the representative and doctor. If the doctor wants a very small or a very large size, the representative will need to bring the right sizes in for that specific procedure. Large sizes will, for example, be used for obese patients.”

Case G – Participant 2: “...as time goes by, we learn how often the doctors work and what quantity of product they use, one gets a good idea which sizes and suppliers they use most of the time.”

Case G – Participant 2: “Consumed consignment stock items are always replenished. It also makes stock takes easier as the system and consignment contracts, for example, state that five pieces of a specific device need to be on hand or items need to be in transit to the hospital. It does sometimes happen that items are consumed and not replaced, this makes counting difficult.”

Case G – Participant 1: “Consignment stock levels are calculated by the pharmacy manager and the inventory team, not the rep. We will generally ask to have two pieces of each item placed on consignment and will then monitor the situation carefully. We will quickly see if an item is a fast mover. When a new item is placed on consignment, it is generally trial and error, but after a month or two, we start to see how many the doctors are using. Levels will be adjusted accordingly. A good rule is one piece plus another as backup, depending on the product. Some doctors use more devices than others; it is therefore hard to decide on a definite level.”

Case G – Participant 2: “The basic rule is one device plus another should anything go wrong with the first one. The rule is therefore two or more of each size. In other instances, we have six to eight devices of each size, so it really depends. Doctors use specific items for years, so we learn what products they use regularly.”

Case G – Participant 1: “The cath lab nurses are in the cath lab daily. They know which theatre lists are coming and should they suspect that inventory is low they will order additional stock.”

CASE H

Case H – Participant 1: “Forecasting is difficult to do, but very important. We have quiet, busy and very busy times. Busy times need to make up for quiet times. Usage in this industry is very precarious and past trends have recently changed significantly.

Case H – Participant 2: “Business is seasonal and forecasts need to be carefully executed. Products are very doctor specific and if a doctor goes on leave, usage comes down.”

Case H – Participant 1: “The whole range needs to be on the shelf, less quantities of the slow movers, but we need the full range. Doctors are brand loyal so that specific brand’s full range needs to be available on the shelf.”

Additional direct quotes supporting the topic can be found in Appendix 6.

5.4.2 Research Question 2 – Is consignment stock management best practice when managing inventory of interventional cardiology medical devices at hospitals?

Research Question 2 attempts to answer the question whether consignment stock management is best practice to manage inventory of interventional cardiology medical devices at hospitals. The aim is to search for answers on the topic.

Table 5.7 summarises the findings from a supply company perspective.

Table 5.8 summarises the findings from a hospital perspective.

Each table is supported by direct quotes from the interviews.

Supply Companies

Table 5.7: Summarised findings on Research Question 2 from a supply company perspective

Case	Is consignment stock management best practice when managing inventory of interventional cardiology medical devices at hospitals?	Short Summary
A	Yes	Cases are not elective. Need the full range to be available. If the case is now, the doctor needs the product immediately. Sister wants to be able to service the doctor. All suppliers are following the same model. Nearly 100% sure it must be best practice.
B	Yes	When the patient is on the table there is no waiting time. If you do not offer consignment stock, you cannot play along. There is no other way into the hospital. It is the only sales process. Neither hospitals nor doctors are willing to take the risk. In South Africa doctors want to be looked after. Hospitals force suppliers into this model. If it is not fast moving, consignment is the only option.
C	Yes	Hospitals will never assume the risk, too much uncertainty. High value and slow moving items will always remain on consignment. Product needs to be available on the spot. Even a lead time of an hour is too long; always something needs to be available on the shelf.
D	Yes	Hospitals like consignment stock because they do not carry the risk of write-offs due to expiries. No need for hospitals to do internal demand forecasting. Hospitals get what they want on the shelf without assuming any responsibilities.

From the feedback, it follows that consignment stock is non-negotiable in this industry and that it serves as the only sales process between supply companies and hospitals. Due to the high value of these devices, hospitals are not willing to take the risk and will

not assume responsibility. It is clear that product needs to be available on the shelf as there are no waiting times between diagnosis and the angioplasty procedure.

CASE A

Case A – Participant 2: “...in elective cases, you can plan in advance. Here you cannot because it is the same as with orthopaedic trauma cases and therefore the full range needs to be available in the cath lab. The case is now, I need it, give it to me.”

Case A – Participant 2: “I think the reality is that, at the moment, consignment is really the only way we can do anything because... It is best practice because that is what everyone is doing. Is there an alternative? Not something that I can think of and not something that anyone else can think of because the reality is that when the patient is on the table, that is the only time that you know what you need. So if it is not there on consignment. Well, I suppose the alternative is for the hospital to buy the products. That is the alternative, but that is never going to happen. As long as companies are prepared to do business on consignment... If you were a hospital manager, what would motivate you to buy a product knowing that you could have it on consignment where you do not have the risk of that stock? I would not. So, I do not believe there is an alternative for the hospitals. For us, it would be ideal if they bought it, but it is not going to happen. And even if all the companies at the same time decided not to take that risk, I do not believe it would change anything because the hospital might say, okay, we will buy it, but we want you to be responsible for the rotation. Then we will be responsible if it expires and they will put a contract in place that really makes it just as bad as consignment. So, I am not sure that there is an alternative.”

CASE B

Case B – Participant 1: “When the patient is on the table, there is no waiting time, after the doctor has done the diagnostic and found a lesion, it has to be fixed instantly. You cannot play unless you commit to consignment stock.”

Case B – Participant 1: “There is no other way to get into the hospital, but to follow the consignment model. Consignment stock is the sales process that the hospitals insist upon and has been ever since it was introduced in the early eighties. The

doctors or the hospitals will not buy the devices because they do not know what they are going to use. It is thus a universal process of market access.”

Case B – Participant 2: “Hospitals will say: ‘If you want to play in this market you need to place your product on consignment in our hospital.’ The supplier thus does not have a choice.”

Case B – Participant 2: “Everyone knows that write-offs do exist. Cardiology and pharmaceuticals have write-offs, so they either have to be fast movers, if not, hospitals force suppliers to adhere to a consignment stock model. They do not want to take on the risk.”

CASE C

Case C – Participant 1: “With the consignment model as it stands, we will never get the hospitals to assume the risk to purchase product that they do not need because of the uncertainty. Until it goes to a system where they have a strict tender-based system where they put everything out on tender at a set price and they award to that tender to say one or two companies. Then they will know the product they purchase is going to be used because the doctors have the choice to use either A or B. Right now, there is a choice from A to Z. Until we can get that collaboration between ourselves and the doctors, the consignment model will not go away in a hurry. We are looking within the consignment products like guide wires and catheters, which some hospitals purchase. If we could get the bulk of them to also purchase those items, it would be fantastic because that is a large volume of consignment at some hospitals. They may not purchase everything, but even if they purchase just what they use on a regular basis that will help tremendously. But your high value items – your stents and balloons, I reckon will stay on consignment.”

Case C – Participant 2: “...you have to carry a minimum amount of product of everything because theatre would always need to have something available even if you have a lead time of something like an hour. They would always still want something in the cath lab, but ultimately you do not have to carry as much...”

CASE D

Case D – Participant 1: “I can understand why they would go for consignment as opposed to direct sales because they do not carry any risk in terms of expired stock and write-offs. They also do not have to do any demand forecasting. So that is why they automatically go the consignment route because they get what they want on the shelf and they carry no responsibility. However, where possible, we drive direct sales and offer combo deals or would give them relief on shelf life. If it is a big account you will say, okay, let us consider an annual order and if we do have shelf life issues at the end of the period, we will consider replacing that stock for free. For example, if they buy a hundred units and we get a return of five, that penetration rate is still much higher than any consignment model elsewhere. So we do drive that and it is a strategy that the business unit managers drive. But for the most part, I do not see consignment going anywhere.”

Additional direct quotes supporting the topic can be found in Appendix 7.

Hospitals

Table 5.8: Summarised findings on Research Question 2 from a Hospital perspective

Case	Is consignment stock management best practice when managing inventory of interventional cardiology medical devices at hospitals?	Short Summary
E	Yes	Diagnostic and action is often taken at the same time, thus no waiting time. Due to vast ranges and sizes, most devices are kept on consignment. Does not make sense to purchase everything, too high risk. Pricing and usage volume will determine consignment or not. We do not have the resources to control consignment stock. More reasons are vast variety, sizes, complexities, doctor’s preferences, value. Fast

		technological change.
F	Yes	Doctor decides what product to use whilst the patient is on the table; product has to be on the shelf. Normal and acute procedures require the stock to be available on consignment. Non-consignment will result in major losses for the hospital. The investment is just too big.
G	Yes	These devices are always on consignment, never part of our own stockholding. Technology changes too quickly, doctors always want the new technology items. It is too risky and expensive. It is in the better interest of the patient.
H	Yes	Consignment is a nightmare for all parties concerned. Most stock in the cath lab is consignment stock. Hospital does not carry the responsibility should the doctors ask for new technology items. Once the doctor is in the patient, he only knows what size to use. Value of consignment stock is too high to carry as hospital's own stock.

From the feedback, it follows that due to the riskiness of the business, hospitals will not assume the responsibility of putting these devices on their stock holding. More reasons were the high value of these devices, the vast range of stock, the pace of technological change and the labour intensiveness in terms of managing the stock.

CASE E

Case E – Participant 1: “Doctors sometimes have planned procedures happening the next day, but diagnostic and action is often taken at the same time, thus no waiting time. In extreme cases, we will phone the supply company and the rep will bring it through, but ideally it should be on consignment or in stock holding.”

Case E – Participant 1: “Most of the stents at this hospital are kept on consignment stock, just because of the vast ranges and sizes of these stents. It does not make sense to purchase everything and keep it in terms of space and keep it as part of our stock holding because you will have to keep such a wide range. So it makes sense for the hospital to manage this type of product on consignment. If not, we will end up with expired stock, stock that we open and then realise we do not want to use, etc. And where we need support, the rep will offer the needed support in theatre.”

Case E – Participant 1: “It is therefore important to review the usage to see how much of what is on consignment and is used regularly so that one can remove those from consignment and move into normal stock holding because the doctor has not changed his practice, he is happy with the product and will be using it for a long time to come until something changes in technology. It will then become the theatre stock controller’s responsibility to manage that including expired stock, dead stock, etc. Consignment stock sitting at the hospital is at such a high value, we would have liked to take it off, but the vast sizes, complexities, doctor’s preferences and variety is just too vast and therefore it will remain on consignment. Our challenge is space, where do we keep it and how do we control it?”

Case E – Participant 1: “The environment changes at such a fast pace, that is why we like the consignment stock model.”

CASE F

Case F – Participant 2: “An angiogram is done first to see what products they need to use. The doctor and his team will then make a call as to what product and size is needed. It therefore needs to be on the shelf...”

Case F – Participant 3: “Patients are assessed when they are on the table and a call is made. The doctor will do an angiogram, sometimes an advanced procedure like a rotablation needs to be performed. He will then plan a procedure for a few days from then. Companies will then be phoned and will deliver what is needed. This is only done for special cases. Normal and acute procedures require the stock to be available on consignment.”

Case F – Participant 1: “Moving away? No, the investment is just too big. The cath lab’s consignment stock value is around R9-million and the theatre’s R11-million; we cannot afford another R20-million on our books.”

CASE G

Case G – Participant 1: “After the necessary steps have been followed to open the product codes on the system, medical devices are placed on consignment. Always on consignment, these devices do not form part of the hospital’s own stock.”

Case G – Participant 1: “I do not see us moving away from consignment stock. Technology in this industry changes too quickly. The moment when new technology is available on the market, the doctors forget about the old technology items and only want the new. In the cardio environment, doctors refuse to deplete the old stock if there is new technology. Their reason is that it is in the interest of the patient. It is therefore too risky to purchase these items and consignment stock remains your best option. I therefore base my answer on A – it is too expensive, these devices are extremely expensive and B – technology changes too quickly. So, no, I cannot see us ever moving away from consignment stock. There are way too many changes happening all the time.

CASE H

Case H – Participant 1: “Consignment in its totality is a nightmare for all parties concerned. The consignment stock value in our cath lab and the two ICUs amounts to around R40-million. Our normal stock keeping totals to around R20-million.”

Case H – Participant 1: “Less than 50% of the stock in the cath lab is our own stock, it is mostly consignment stock. We need to keep the whole range on the shelf.”

Case H – Participant 2: “The big advantage of consignment is stock is that when a doctor returns from a conference where he saw a product that he likes and would like to switch to compared to what he was using at the time, we will phone the supplier and ask him or her to uplift their stock. We do not carry the responsibility of the stock.”

Case H – Participant 2: “The value of consignment items is just too high for the hospital to carry that responsibility. It is literally capital stuck where we could have used it elsewhere. It is already hard managing our own inventory; imagine adding consignment stock to the equation. In an ideal world, all stock should be on consignment, doing so we will not carry any responsibility whatsoever. You will only pay for what you use.”

Additional direct quotes supporting the topic can be found in Appendix 8.

5.4.3 Research Question 3 – Is useful information effectively shared between hospitals and suppliers within the interventional cardiology medical devices industry?

According to Goldratt (1990), meaningless information availability is called data and is not helpful at all. The dilemma the world finds itself in is that it is drowning in oceans of data, but that useful information is seldom available. Goldratt (1990) defined data as being any answer while information is “the answer” to a question asked. In this study’s context, the complete answer to the following question is helpful: What must move to the next link today / tomorrow?

Research Question 3 attempts to answer the question whether useful information is effectively shared between hospitals and suppliers within the interventional cardiology medical devices industry.

Table 5.9 summarises the findings from a supply company perspective.

Table 5.10 summarises the findings from a hospital perspective.

Supply Companies

Table 5.9: Summarised findings on Research Question 3 from a Supply company perspective

Case /s	Reason for sharing information	Communication medium	Between which parties?	Increase: inventory or availability	Useful information effectively shared?
A, B, C, D	Forecasting purposes	One-on-one meetings	Product manager, sales and supply chain	Inventory	No
A, B, C, D	End-user consumption	E-mail / Fax / Telephone / OrderWise (a form of EDI, but not fully integrated)	Private Hospital and supply company	Availability	Yes

A, B, C, D	End-user consumption (lack thereof)	None	Public hospital and supply company	None seen that public hospitals rarely communicate consumption signals	No
C	Measure response time and stock availability	OrderWise / Order Logistics (EDI) – Order and validating system	Between Mediclinic, Netcare and the supply company	Availability	Yes
C	End-user consumption (lack thereof)	Client visit / One-on-one meetings	Reps and public hospital staff members – Reps visit hospitals nearly daily	Availability	Yes
D	To understand what the doctor needs	One-on-one meetings	Company representative meeting directly with the cardiologist	Availability	Yes

From the feedback, it follows that all four of the supply companies were relatively satisfied with the way in which private hospitals communicate consumption signals to them. Many of them alluded to the fact that doctors are difficult to talk to due to their busy diaries. This makes initial buffer management hard as companies need to place consignment based on a forecast without knowing if that is what the doctor needs.

All four companies raised the concern of dealing with the public sector. One of the supply companies, however, tried to actively bridge that communication gap through supplying the public sector with equipment like photocopiers. They also ensure that company representatives visit these hospitals a few times each week to collect the consumption signals and to walk them through the invoicing process, something which, according to the interview findings, the other companies were not actively willing to do.

The challenge in the public sector is to get the consumption signals faster to the supply companies. The study shows that the public sector does not always have the needed equipment to send the necessary consumption signals to the suppliers and that company representatives play a pivotal role to help walk the signal through the system

in order to have the used products invoiced, which will trigger the replacement of stock to the respective hospitals. Doing so, the supply company will not only be remunerated on time, the hospital will also promptly receive its replacement stock in order to serve their patients and ultimately saving lives in the process. It is therefore mutually beneficial to both supply chain links to get the signal communicated promptly.

A suitable EDI link between hospitals and supply companies is lacking. OrderWise is a step in the right direction, but not all hospitals have adopted the technology as yet.

Most of the information currently shared is believed to be helpful regarding the question: 'What must move to the next link today / tomorrow?'. However, there is room for significant improvement.

Additional direct quotes supporting the topic can be found in Appendix 9.

Hospitals

Table 5.10: Summarised findings on Research Question 3 from a hospital perspective

Case /s	Reason for sharing information	Communication medium	Between which parties?	Increase: inventory or availability	Useful information effectively shared?
E, F, G	End-user consumption	E-mail	Hospital stock controller and company customer services department	Availability	Yes
E, G	So that stock on the shelf match the consignment contract	One-on-one, telephone, e-mail	Hospital and supply company	Inventory	No
F	To improve flow into the right direction	Suppliers label the parcel stating cath lab	Supply company dispatch and hospital pharmacy	Availability	Yes
G	Doctors often know in advance what stock will be used, but the signal is not	None. The doctor assumes that the stock is	Doctor / nurse and supply company / representative	Inventory	No

	sent to the supplier.	available on the shelf due to consignment			
H	To inform the supply company to trigger a replacement before hospital has even processed the usage	Rep on-site at the hospital	Rep and supply company	Availability	Yes
H	Out of stock notification letters	Email / post or telephone call	Supply company and hospital	None	Yes, it advise on the lack of availability

From the feedback, it follows that consumption signals are sent to supply companies timeously. Unhelpful information exchange pertaining to consignment contracts was observed. Signals between hospitals and supply companies are lacking where doctors know in advance what sizes will be needed, but this is not communicated.

Additional direct quotes supporting the topic can be found in Appendix 10.

5.4.4 Research Question 4 – Is waste present within the supply chain of interventional cardiology medical devices?

Research Question 4 attempts to answer the question whether waste is present within the supply chain of interventional cardiology medical devices. The aim is to search for answers on the topic.

Table 5.11 summarises the findings from a supply company perspective.

Table 5.12 summarises the findings from a hospital perspective.

Each table is supported by direct quotes from the interviews.

Supply Companies

Table 5.11: Summarised findings on Research Question 4 from a Supply company perspective

Case	Is waste present within the supply chain of interventional cardiology medical devices?	Short Summary
A	Yes	Write-offs are a major problem. Where you have consignment, you have a problem. Carrying the full range is the problem because slow-movers cause the write-offs. Time wasted getting multiple signatures to sign off orders. Items written off will not be replaced. Rigid and tedious returns policy. There is too much stock in the system.
B	Yes	Items go missing. Incorrect items are opened and rendered useless. Reps waste time doing stock counts. Lost sales due to stock outs. Long supply lead times from international distribution centre (DC) lead to lost sales. When new technology is available, doctors discard previous generation products, which leads to obsolescence. Unrealistic return policies to DC. Active stock rotations not driven as a priority. Administrative errors leading to delays in getting the pull / consumption signal from the hospitals.
C	Yes	Expired stock due to the inability to fully phase out old technology items. Expiries due to slow moving stock. If stock falls below a certain time to expiry, it cannot be returned to international DC. In-transit damages. Stock count variances due to lost stock.
D	Yes	Stock can be returned to DC, but many prerequisites to be met first like shelf life, value and global demand. Reps spend too much time counting, so that has decreased. Due to contracts, missing stock will have to be written off by the supply company. 30% penetration rate – only 3 out of 10 items on consignment are used, 7 are written-off. In-transit damages.

From the feedback, it follows that all interviewed participants allude to stock write-offs being the major cause of waste in these supply chains. Massive amounts of stock are

written-off each year. The major cause of this is that the full range needs to be on the shelf at all times. Small and big sizes move very slowly and are usually written off. Administrative errors and delays are listed as another concern where in-transit damages and the wrong opening of packages are listed as further forms of waste. International DCs make it very difficult for their South African counterparts to return non-moving stock to them.

CASE A

Case A – Participant 2: “Write-offs is a problem, it is our biggest headache. Where you have consignment, it is a problem. Hospitals do not give a damn because at the end of the day they know you are going to service them to the best of your abilities. You give them what they need.”

Case A – Participant 2: “The same as at other supply companies, we also have a massive drive on reducing stock levels, reducing to optimal levels. That is the key because obsolescence is probably the biggest killer of businesses like ours. It is not only the consignment model. It is the fact that you have to carry a range. And the reps will tell you, well the doctor is not going to use it if he does not have the full range, which is a load of nonsense but, you know, it is just the way it is. The reality is, your obsolescence is not in your fast-moving items, those are fine. It is your outliers that are your problem. That is what you cannot get rid of.”

Interview question: Does your company see write-offs as a cost of doing business?

Case A – Participant 2: “We see it as an unacceptable cost of doing business. Certainly, the levels that we are experiencing due to the market, we see it as an unacceptable cost of doing business. I guess that is the fairest answer I can give you. Yes, it is a cost of doing business, we get that. But the levels at which we are writing off, and other companies feel exactly the same way, is not an acceptable level and is not being considered in reimbursement. Our write-off is a round 5% of sales, our aim is to drop that to 2%. I think the market average is around 8%, but let's be realistic, a 5% write-off in any business is unacceptable.”

Interview question: Apart from write-offs, what other forms of waste is present in this supply chain?

Case A – Participant 1: “Hardly any. You will find a doctor opening something and it was not right, but it is a small percentage. And generally speaking, we can get reimbursed for those. It is very seldom that we do not get paid for that.”

Interview question: Do you often lose sales due to stock-out situations?

Case A – Participant 1: “No, not often. It happens on occasion, but it is definitely not something that we do often. That is an indication that we carry too much stock.”

CASE B

Case B – Participant 1: “Suppliers have contracts with all customers, if an item goes missing or is unaccounted for, the customer is responsible. If they open a product it cannot be used again.”

Case B – Participant 1: “For reps with a large area, the issue is stock taking. They cannot afford the time doing stock takes when they should be getting sales. When doing the stocktakes, you do bump into doctors and cath lab staff members. The stock controller is also another very important person in the whole scheme of things as he is the person that allows you to put stock on the shelf. They can also give you inside info, warning you of new entrants, when your stock is moved around, etc. So do not always focus on the inventory or pharmacy manager...”

Case B – Participant 1: “...doctors can use two devices in a procedure, it does happen. If you only have two items on consignment and the doctor wants to use your product the next day, there is a lost sale. He wants the product there and then. You cannot predict what size is needed; anatomically patients differ vastly in size. There are not any averages in this industry, they all vary.”

Case B – Participant 1: “Long supply lead times are a problem and directly result in lost sales. Further supply delays out of the international supplying plant make it even worse.”

Case B – Participant 1: “Doctors will not use the old range if they have better technology available on the shelf.”

Case B – Participant 1: “...in terms of write-offs, there is an industry norm of around 7% of sales. Introduction of new products and phasing in of new technologies need to be managed carefully. One should also have the option to return non-moving stock to the source. Margins in this business are high, but it is not because the products are so

wonderful, it is because the cost of doing business is so high, write-offs should be seen as the cost of doing business and not as an expense coming off the bottom line.”

Case B – Participant 2: “Write-offs is a massive issue. Another form of waste is stock damages occurring in transit.”

Case B – Participant 2: “Stock rotations have not been properly performed in the past, but it will be done now, it is part of the reps’ key points to actively do rotations and to have a plan in place. Hopefully, less stock will be written off.”

Case B – Participant 2: “Some hospitals are well managed and quick to getting the signal to you. Others are sloppier. Some make mistakes, for example, invoiced in the wrong way, gave you the wrong usages, etc., then needs to credit and re-invoice, pricing might be problem and these cause delays. 80% of the time they are on-time and 20% late. The private sector is quite clued up, government is a challenge. The question is: Do you have the necessary resources to always follow up on government usages?”

CASE C

Case C – Participant 1: “...we can do a phase out of old technology stock when we launch a new product; I have found that a phased approach works best. State hospitals will take the balance of unsold items. Planning and execution is therefore important, but might be left with a little at the end of it, which will eventually expire.”

Case C – Participant 2: “Obsolescence is a problem and that is the reason why we have implemented the par levels, because we were keeping too much stock on consignment. What happens then is stock gets sent back to the warehouse at a point where it cannot be sold anywhere else. Stock that has reached 30 days or less in terms of shelf life, we will literally sit with them until they expire and then write them off. So, with the par levels we are trying to minimise the excess inventory, which will ultimately become obsolete. So yes, we are not there yet.”

Case C – Participant 2: “We do try and rotate stock locally, which falls within a certain expiration range where we cannot send it back to our international distribution centre. This is rep driven. We also put ‘Use me first’ stickers on the stock close to expiration, which highlights to the lab staff what needs to be used quicker and then you can work through it like that. But that is an exercise, which we constantly need to check and put

out there to the reps. It takes a lot of hands on intervention, monitoring and understanding your shelf life to really make it work. You quickly see when the reps stop doing that for a bit, you see the build-up of the short-dated stock. It does, however, require a lot of effort and that is the drawback of carrying so much consignment stock.”

Case C – Participant 2: “...occasionally, we do get in-transit damages depending on our courier company handling our products with care. Although we put fragile stickers on every single parcel, eventually it becomes like not seeing the ‘wood for the trees’, so they stop seeing it. Biggest cost is write-offs due to expired stock, stock count variances and obsolescence.”

CASE D

Case D – Participant 1: “To be honest, the hospitals very seldom stick to the consignment agreements. It is put in place, everyone feels very comfortable and it has all of the necessary requirements. For example, they expect us to count every month. We cannot count every month; it is impossible. Since my days of running consignment, it was every month, then every second month, then twice a quarter. To find that balance not to have sales reps count stock all the time, but actually sell now, we have moved it to once a quarter because it is just not feasible with the number of hospitals and following up of queries. So, we are in breach of the contract and in terms of the contract, if there is a query now, they actually have the advantage. They will say here is a query, show me last month’s count. And we will say, well we do not have it. And then they will drive the write-off. I will rather take the write-off.”

Case D – Participant 1: “Stock on consignment outweighs stock kept in our local warehouse by a big margin. If we put ten line items on the shelf, we will sell three and write off seven. Our penetration percentage is thus only 30%. As a whole, we have bucket loads of scrap [write-offs] and it has become the norm. We do not even question it anymore because that is what you need to do. So, we are trying to see how we can minimise what is on consignment without impacting sales. Our service level percentage [availability] is around 95%, so our backorder percentage is not that bad. So, from warehousing point-of-view, we are fine, but consignment-wise there is still a lot of work to be done. Our scrap as a percentage of sales is currently on 2%, our target is 1.2%, but in order to do so, we will have to improve on our penetration percentage.”

Case D – Participant 1: “Damages are minimal, although we do track it, it is very small. The biggest portion of waste I have is expiry due to consignment.”

Additional direct quotes supporting the topic can be found in Appendix 11.

Hospitals

Table 5.12: Summarised findings on Research Question 4 from a hospital perspective

Case	Is waste present within the supply chain of interventional cardiology medical devices?	Short Summary
E	Yes	Expired stock. Incorrect stock items’ packaging opened. Consignment processing process is long and tedious. Time wasted retraining stock controllers. To keep everything updated takes time, for example the consignment contracts and the electronic register. Delays getting the signal to the supply companies.
F	Yes	Old product ranges replaced by new technology. In-transit damages. Product malfunction. Product expiries due to very slow movement. Bottleneck sometimes sit with nursing, delay the signal to suppliers. Reps get lazy and stop counting their stock. Packaging opened and not used. Head office admin delays.
G	Yes	Inventory goes missing and cause discrepancies. Administrative price queries and code discrepancies cause delays getting the signal to the suppliers. Products are opened by mistake.
H	Yes	Technology change so quickly, rendering older products useless. Missing stock due to hospital staff not following procedure. Reps do not always count monthly as per the consignment contract, missing stock will then become their responsibility. Wrong items opened by nurses, so doctors rather ask for product and brand specific. Expired stock is a known problem in this industry.

From the feedback, it follows that hospitals are aware of the high level of write-offs in this industry although it does not affect them much. They were more concerned of stock going missing under their control and the wrong products being opened by cath lab staff members. They alluded to the fact that the consignment process is tedious and time consuming.

CASE E

Case E – Participant 1: “...we will end up with expired stock, stock that we open and then realise we do not want to use...”

Case E – Participant 1: “The consignment process is a long process, so will rather keep it as our stockholding in the event of high volumes being used.”

Case E – Participant 1: “Reps have to count their stock once a month as per procedure. They have a register in place and sign it off each month when they check the stock. They check expiry dates, etc. and sign along with the theatre stock controller, both have to be happy. If reps do not do that and something gets used and not recorded, responsibility lies with the supply company; if they did follow procedure, responsibility lies with the hospital. Losses do not happen often, but it is a financial risk to the business and that is why strict control is followed. It is not the theatre nurse’s responsibility to count stock or to check expiries.”

Case E – Participant 1: “I think our biggest challenge is the turnaround time of goods consumed on consignment. That is really our biggest challenge, getting that item billed to a patient as quickly as possible and getting the same items checked by the supplier reps. In the cath labs, the reps are very regular, they sign and make sure. They are better in the cath lab than the rest of the hospital. These challenges of getting the patient billed on time are really internal operational issues; reps sometimes uplift stock and do not let us know, full control is therefore also a challenge. And to keep everything updated – the contract, the electronic register, etc. One almost needs one dedicated person handling consignment. Too many people involved can cause the whole process to fall flat. Delays do happen where the order is not sent off to the supplier in time, or the person does not follow up, the follow up never happens. Examples will be whether the supplier actually received the order and sent the invoice. These delays happen all the time. The only time I will know that we have not received an invoice is when the patient is discharged. I can see on the report that the person has been discharged and why the file has not been closed and consignment is one of the many reasons. We therefore run this report daily and ask for feedback from the

theatre stock controller. Theatre stock controllers cannot expect to work from this report only, but need to be proactive. No patient should be discharged with consignment outstanding, but it all depends on how good the stock controllers are. Some people are untrainable.”

CASE F

Case F – Participant 2: “Product ranges are sometimes discontinued due the availability of new technology. The cath lab does not deplete the old range first. The old range is removed and replaced by the new range.”

Case F – Participant 2: “Some items get damaged in transit and others very seldom malfunction. In these circumstances, a product complaint form will be filled out. The supplier will investigate and will then replace it. If a product is missing, we will go back to registers and go find it, but suppliers will only replace if there is an order number.

Case F – Participant 2: “Expiries do, however, happen, some items only really move once a year.”

Case F – Participant 2: “If there are many cases, nursing cannot always sign the charge sheet, so they will have to wait until all cases have been completed, only then does it go through to the stock controllers and the suppliers will only be informed the next day.”

Case F – Participant 2: “Every month, a consignment valuation is done. If a rep gets lazy, stops counting his or her stock and after four months says something is missing, I will ask them when last they were here. If they start back-tracking, it will become their problem, I see this as school fees. If their managers have a problem, they can phone me, but the contract states that they need to count their stock once a month.”

Case F – Participant 2: “...the doctor or scrub nurse will check first because if the packaging is opened we will have to pay for it.”

CASE G

Case G – Participant 1: “...there are cases where inventory goes missing; company representatives are then asked to check their stock more often. As a rule, company representatives need to count their stock on consignment at least once a month. If they do not, the hospital will not take responsibility in the event of inventory discrepancies.”

Case G – Participant 1: “...suppliers often take three days to up to a week before invoices are sent for used stock to the hospital. There are often price queries and code discrepancies, the consignment coordinator needs to resolve these and it keeps her very busy. This delay is bad because at this stage, inventory in the cath lab has also not yet been replaced.”

Case G – Participant 1: “It does not often happen that products are opened by mistake. If it does, however, happen, the hospital takes responsibility and it will be a write-off for the hospital.”

CASE H

Case H – Participant 2: “Technology is forever changing at a very past pace. Older products are often rendered useless because doctors want to use the best technology available.”

Additional direct quotes supporting the topic can be found in Appendix 12.

5.5 Simulation Exercise Results

5.5.1 Simulation Period

The simulation exercise was performed using real data from 10 March 2015 up to and including 2 July 2015. The results of the simulation exercise are presented briefly as further discussions of the results are done in Chapter 6. The data is presented in a logical order.

Due to time constraints, the simulation was performed using real data over a relatively short amount of time. Four months’ data was used in this study. In order to get realistic results, data over a three months’ timespan has to be used; the results of the study can therefore be classified as being realistic.

Two simulation exercises were conducted. One with a 15-day lead time after consumption has taken place and another with a 2-day lead time. The reason for the difference was that some supply companies’ operations differ from others and both simulations had to be representative of the supply companies forming part of the interventional cardiology industry in South Africa.

5.5.2 Theory of Constraints (TOC)

TOC aims to protect the following two factors:

1. **Availability** – to always have the right inventory available on the shelf. Availability can be used as a marketing tool opposed to the usual thinking that all that matters is price. If availability can be guaranteed, products can often be sold at a premium as customers are willing to pay more for immediate availability. These offers are also called “mafia offers” where suppliers leverage the market to their advantage.
2. **Reliability** – how reliable a supplier is in terms of promised lead times.

5.5.3 Results

Real data was supplied by one of the supply companies. When analysing these results, the simulation generally starts by generating a sales versus stock location chart as well as a sales versus SKU chart. These charts help to understand which products are moving the fastest and which stock locations contribute to the highest volume of sales. The results can be seen on Appendices 13 and 14. It is quite common that long tails are found to be apparent on these charts and this simulation was no different. A long tail is an indication that only a small amount of products and customers generate the largest volume of sales and that the bulk of the SKUs hardly ever move. The slow moving items and stock locations represent the two tails in these appendices. The irony of this is that stock-outs are common on fast moving items and overstocks are common on slow moving items. These results are on average similar across all industries. In TOC terms, this can be described as low availability of popular SKUs, ultimately leading to stock-out days and lost throughput. Too much inventory is carried and this is common on slow moving / unpopular items.

Symphony then provided a list of all SKUs, which are out of stock, listing them as high priority items. This output takes in-transit quantities into consideration and marks them as such. The total stock-on-hand at the central warehouse as well as stock available on consignment was described as inventory-at-site. For items that did not have any inventory in transit and neither inventory at site were described as a double black, which is an indication of high risk items. Symphony therefore prioritised the highest

risk items, which a user of the data needs to action first. Symphony proposed an increase in the buffer size, which the user had to accept; secondly an order was proposed, which had to be expedited due to the urgency of the matter.

Symphony made it easy to see which stock locations were out of stock and which were overstocked. This was compared with a simulated state over the same period. Symphony can also take care of stock rotations by identifying overstocked items and pointing the user to where stock needs to be sent to due to a demand within that product's buffer requirement.

In order to demonstrate the differences between the current and simulated states from a dynamic buffer management perspective, the results of only two different SKUs are presented. This helps to explain the various concepts in a simple and practical manner. These results can, however, be applied to all SKUs within a product range.

The simulation clearly illustrates how a push distribution environment would differ to that of a pull distribution environment. The simulator used daily stock-on-hand as well as daily consumption (sales) data from the current environment and plotted the behaviour of each SKU at each stock location.

Example 1 – Product A

Current state:

Appendix 15 indicates a standard SKU chart for a certain size balloon catheter at a private hospital in Pretoria (consignment location). Two pieces of this SKU were on hand at the cath lab at the time. It is clear that the SKU was consumed in quick succession on the 8th as well as on the 19th of March, which resulted in a stock out. This hospital was out of stock from 19 March up to 14 April. On 15 April, the cath lab was replenished with one piece, but the SKU was consumed on 3 May, which resulted in another stock out. This time round, the cath lab was promptly replenished with two pieces on 20 May and was fully stocked. It does, however, seem that this SKU might now be in an 'overstock' position as it has not moved in 2 months, up to 3 July when the simulation period ended.

Simulated state:

The simulator uses the exact same consumption (sales / usage) data as the current environment, but uses dynamic buffer management (DBM) and buffer replenishment to illustrate how stock-on-hand would differ to the current environment. Appendix 16 indicates how a buffer and demand-driven system would manage the SKU at the specific stock location using a 15 day lead time. The 15-day lead time can be changed to any other amount of days in order to suite the supply company's supply chain operations.

The first signal to replenish came at the very first consumption signal on 8 March. The simulator then "placed an order". That order will come in 15 days' time after the consumption signal triggered the flow. The same happened for the second consumption signal on 19 March. The DBM "too much green" calculation starts once the buffer has been filled to the top of the green band. As soon as the decrease trigger has been reached, the simulator will automatically decrease the buffer. At the third consumption signal on 3 May, the stock on hand drops to the top of the green band again. The 'too much green' calculation is not active on buffer sizes equal to 1 as most hospitals need to keep at least one of each range in-line with the consignment contracts. There will, therefore, be no further inventory decreasing events for this SKU at this level.

In this example, Symphony software has managed to decrease the overstocking of this SKU at this stock location.

Example 2 – Product B

Current state:

Appendix 17 indicates the SKU chart for a drug-eluting stent at a government hospital based in Cape Town. It is clear that the SKU was consumed on 8 May, but was never replenished afterwards. Stock-outs are a clear indication of lost sales. Symphony can calculate this lost throughput by using a certain formulae. The potential damage is measured in throughput value days (TVD) and is determined by multiplying the SKU throughput by the average consumption of items per day, then multiplying the answer

by the number of days the item is out of stock. This number of days a SKU is out of stock is also known as being in the black zone (Schrageheim et al., 2009).

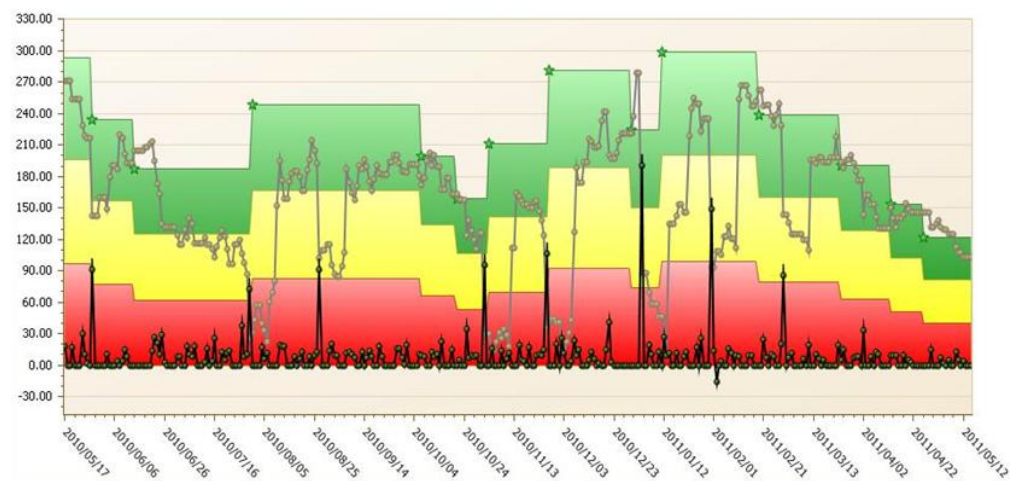
Simulated state:

In this example, the simulation lead time for this SKU at this location was set at two days. Appendix 18 indicates the simulated SKU chart of the same SKU. As soon as the SKU has been consumed on 8 May, a replenishment signal was sent and an “order placed” to replenish the buffer and was replenished 2 days later on 10 May. This ensured 100% availability of the SKU at the stock location.

The simulation applies a simply ‘too much green’ or ‘too much red’ calculation to each SKU at each stock location and immediately realigns the supply chain to increase stock holding of faster moving SKU’s, and reduce stock holding of slower moving SKUs.

The following figure illustrates the potential success, which can be achieved using DBM for high volume products operating in a fluctuating market environment:

Figure 5.1: DBM in a fluctuating market environment



Source: Inherent Simplicity output

5.5.4 Summary report

Two different summary reports were generated, one based on a 15-day lead time and the other on a 2-day lead time (refer to Appendices 19 and 20). Both results were presented in the same format and are discussed in more detail below:

- **Simulation results** – these are the results of the simulated state. The simulated state is a snapshot of what the situation would have looked like under conditions of the simulation
- **Reference results** – the reference results refer to current state, also better known as the status quo
- **Improvement** – here the difference between the simulated results and the status quo is presented.

It is clear that significant improvements can be achieved using the software, which is built on TOC methodologies where flow is triggered by end-consumer pull. The most profound result is that inventory can potentially be reduced by around 20% for both scenarios, whilst stock availability can be increased by around 32% in the 15-day lead time scenario and by a mammoth 85% in the 2-day lead time scenario.

What this means is that sales can potentially be increased because of higher availability of product on the shelf. Inventory will flow to where demand most likely will come from and not based on assumptions or sales forecasts. The outcome will be an overall reduction of inventory across the chain. It is clear that the result will show a decrease in inventory days as higher sales will be achieved with less stock in the system. This will decrease the company's operating cycle, which will free up cash flow.

CHAPTER 6: DISCUSSION OF RESULTS

6.1 Introduction

The purpose of this chapter is to interpret and discuss the results laid out in the previous chapter. The results are discussed in terms of the research questions and comments are made whether the findings were able to answer the research questions and whether the research objectives were met. The findings are discussed in the light of the literature in Chapter 2.

Battini et al. (2013) admitted that supply chain management in the healthcare sector is confronted by a plethora of challenges. They also stated that healthcare is a less studied sector and that high demand volatility can be listed as one of the reasons for being a neglected area of study. It is believed that healthcare systems paid little attention to inventory management systems. This is apparent looking at the high levels of inventory present within the system due to poor stock management practices and poorly calculated safety stock and other inventory buffer levels.

6.2 Research Question 1 – Is end-user consumption used as the trigger for flow of interventional cardiology medical devices?

Research Question 1 consists of two research sub-questions. The findings for each sub-question are discussed in the following section.

6.2.1 Research Question 1A: Is end-user consumption used to build the buffers in the cath lab?

Depicted in Tables 5.3 and 5.5, supply companies and hospitals both agree that buffers are built on forecasts; however, products were in reality pushed onto the downstream links. Spearman and Zazanis (1992) described forecasts as push policies based on anticipated demand. Buffers do not only safeguard supply chain links against supply variations, but also against variable demand coming from end-users and other downstream links (Nag et al., 2014; Schragenheim & Burkhard, 2007).

Forecasts used in this environment are based on past sales averages and future estimates. Assumptions are made in terms of how many pieces of each item need to

be kept on the shelf in the various cath labs across the country. Pharmacy staff members and reps consult with each other and with doctors in order to understand the doctor's consumption patterns better and to build the required buffer in order to satisfy his demand.

All participants (supply companies and hospitals) agree that the whole range of a specific product line needs to be available on the shelf and that at least one piece of each item needs to be available, should the doctor call for a specific size whilst the patient is on the operating table. The challenge is that the middle sizes are generally the most popular from a consumption perspective and the very small and very big sizes are moving extremely slowly and often expire whilst on the shelf in the cath lab. Large enough buffers of the "popular" sizes are often not kept on the shelf. This leads to the situation that popular sizes often run out of stock and leads to lost sales. In other instances, stock locations are often overstocked with slow-moving items.

In one of the supply company cases, when a new product line is launched, large quantities of product are pushed onto the shelf as a marketing tool and to create awareness and product presence. Inventory availability is, hence, not the only objective, but also serves as a marketing tool to create awareness in the minds of the hospital staff members. Huang et al. (2012) and Nag, Han and Yao (2014) explained that many companies follow push policies in an attempt to satisfy customer service levels. They furthermore argued that push systems tend to carry excessive inventory and safety stock levels. TOC principles, however, suggest that low inventory pull strategies can be sufficient without jeopardising customer service levels. These service levels are achieved through availability of inventory at the required stock locations (Schrageheim & Burkhard, 2007). The simulation results affirm that availability can be increased whilst inventory across the chain can be reduced. Chin et al. (2012) proclaimed that the bullwhip effect can be eradicated by applying TOC solutions through dynamic buffer management and frequent replenishment based on end-user pull. If replenishment is done on a regular basis and only after consumption has taken place, buffer sizes can be small.

Goldratt's generalised concepts linked fittingly with the research results on the topic of buffer management (Goldratt, 2009). The four concepts were:

1. There has to be a clear focus on improving flow. Effective flow and consistent lead times have to be amongst the major objectives of any operation.

The results show that buffers are built based on assumptions and sales forecasts. The latter does not contribute to flow effectiveness as stock is pushed onto downstream links. Lead times are found to be relatively consistent in this industry and supply from international DCs is described as being reliable.

2. To maximise flow, there have to be ways to avoid overproduction. Overproduction causes inventory to accumulate downstream along the supply chain, which results in increased lead times, negatively affecting flow within the system. Practical mechanisms have to be implemented to communicate to the system when not to produce.

From the interviews, it emerges that vast amounts of stock are present in downstream locations at the cath labs across the supply chain. Hospital staff members can trigger further flow to these consignment stock locations without supply companies asking many questions. The problem is that stock often flows into these buffers based on hospital staff members' assumptions or supply company forecasts and not based on end-user demand.

3. In order to maximise flow, all local efficiencies have to be abolished. Whole system thinking opposed to local optimisation should be the focus.

It is clear from the findings that local optimisation dominates in this industry. Each cath lab is stocked for its own "selfish" reasons, carrying as much stock as possible and ignoring the overall wellbeing of the total system. Active stock rotations and returns to local DCs are not popular actions taken, as was found in the interviews. Buffers and ultimately flow are therefore not optimised and the system is rigid.

4. There needs to be a focusing process in place to help balance flow.

Focusing processes are absent in this industry. Flow is unbalanced and buffers generally are only reviewed and adjusted once every quarter.

All supply companies and the hospitals agree that buffers were built on forecasts (expected future sales), which might come from a specific cath lab. Company representatives, doctors and pharmacy managers are among the role players influencing these decisions. Huang et al. (2012) agreed with this view, arguing that

forecasts are still an important input as they serve as the initial level within a pull system in order to determine and adjust the required inventory levels within a system. This adjustment is called sizing the buffers. Huang et al. (2012) and Nag, Han and Yao (2014), however, explained that these initial push policies tend to carry excessive inventory and safety stock levels in an attempt to satisfy customer service levels. This was found to be true, taking into consideration the amounts of stock sitting on the shelves on consignment. The high amount of write-offs also bares evidence of that.

According to TOC principles, dynamic buffers need to be calculated based on end-user consumption and should not push products onto downstream supply chain links. The simulation exercise supported the interview data exceptionally well, showing proof that too much stock is kept at downstream links. The simulation exercise proposed that dynamic buffer management needs to be used to manage the buffers of inventory kept on consignment at hospitals. Dynamic buffers react instantly to pull signals in the market. The Symphony software package immediately suggested to increase the buffers on the fast moving items and to reduce the buffers on the slow moving items. On many of the slow-moving items Symphony suggested a buffer of zero. It was, however, obvious from the interviews that in most circumstances, the hospital expectations were still to have at least one piece of each size on the shelf. Symphony can be manipulated so that at least one piece of each size is kept on the shelf. This will, however, need to be a business decision as it does not make logical sense to carry stock that never moves.

Janse van Rensburg (2014) was confident that dynamic buffer management solutions will have an immediate effect on improving profitability within supply chains. He was convinced that dynamic buffers need to be present in order to avoid overstock as well as stock-out situations. The aim of the software solution is to ensure availability, but also to keep stock levels as low as possible without jeopardising sales. Replenishment lead times are, therefore, also taken into consideration. Dynamic buffers adjust themselves in line with daily consumption and are, therefore, highly reactive to consumption fluctuations.

In conclusion, the findings show that end-user consumption is not used to build inventory buffers at cath labs. The findings fully agree with the literature. From a TOC perspective, there is no other way to size a buffer initially, but to use a forecast. But then, in order for buffers to reflect reality, dynamic buffer management needs to be employed, which does not utilise forecasts anymore. The current reality, which is also the core problem, is that inventory buffers are built based on forecasts, not only initially.

The effect is surpluses and shortages across the supply chain. Applying TOC principles through dynamic buffer management therefore has significant potential in this industry. Dynamic buffers are short-term forecasts and make provision for short-term demand and what will be used within the next couple of days. Because the system will be nimble enough to react, less stock can be carried across the chain.

6.2.2 Research Question 1B: Is end-user consumption used as the trigger for flow after product is used in the cath lab procedure?

From Tables 5.4 and 5.6, it was obvious that supply companies only replace consignment stock after receiving the consumption signals from the hospitals. This consumption signal is better known as a pull signal. The results also showed that supply companies do not ask questions whether the product really needs to be replaced by analysing the stock location where the consumption signal came from. In most instances, whenever the invoice is sent to the hospital where consumption occurred, replacement stock accompanies the shipment. Hospitals expect stock on hand in the cath lab to match the consignment contract and the quantities agreed therein. Should supply companies decide to increase or decrease quantities on consignment, stock quantity addendums need to be added to the contracts. Supply companies mentioned that from their perspective, hospitals are not strict when it comes to the inventory levels as laid out in the consignment contracts and will most probably get away with not replacing the consumed stock should they feel there is sufficient stock left on the shelf.

Zhang and Cheung (2011) stated that to a large extent, supply chain management is both a science and an art that together aim at precisely matching supply with demand. From the interviews, it was clear that after the consignment buffers have been built, product only flows after end-user consumption has occurred. This concurs with the findings by Huang et al. (2012) that buffers serve as the necessary input, which supports a pull system. Strong evidence was found across all interviews that pull policies in this supply chain are firmly in place and that flow is only triggered after receiving a pull signal from downstream links. Nag et al. (2014) characterised these pull supply chains as systems where inventory decisions are made in reaction to market demand. It was however found that in order to keep the supply chain lean, the calculation of the buffers is a highly important task. Reacting on end-user consumption

alone, therefore, is not good enough; the supply chain as a whole needs correctly sized buffers to start off with in the first place.

The perception in the market was that more stock on consignment leads to an increase in the availability of inventory across the chain. It was obvious from the simulation results that this perception is incorrect as too much inventory is placed in the wrong locations, which actually decreases availability across the chain. TOC principals suggest dynamic buffers, which are small, but backed by a system where replenishment is swift and batch sizes are small. Inventory should rather be stored in a central location like a local warehouse. Judging from the interview data, replenishment tasks are completed within a day and batch sizes are generally as small as one piece; there is hence not a reason why buffers cannot be kept to a minimum. Nag et al. (2014) argued that high availability and responsiveness form part of agile paradigms. It therefore will be optimal to follow a Kanban type system where product is pulled on a just-in-time basis at exactly the right time. In this industry, this pull occurs at the time where product is consumed on consignment at the hospital (Kumar et al., 2013).

In conclusion, the findings show that end-user consumption is used as the trigger for flow after a device is used in the cath lab. The findings agree with the literature. It, however, is important to note that after buffers have been sized, product should only flow when there is actual consumption from the buffers and not for any other reason (Schrageheim & Burkhard, 2007). Additional inventory therefore must not be pushed onto downstream links without valid reasons for doing so. The ideal will be to have EDI links with downstream members where stock is replenished based on real-time consumption data. Kumar et al. (2013) named this a consumption-driven replenishment system.

6.3 Research Question 2: Is consignment stock management best practice when managing inventory of interventional cardiology medical devices at hospitals?

From Tables 5.7 and 5.8, all participants agreed unanimously that consignment stock management of interventional cardiology devices is the only sales process currently dominating the industry. Hospital staff members mentioned that moving away from the consignment model is non-negotiable because of the riskiness of the business. Due to the majority of these portfolio items being slow moving, the risk of write-offs is just too high for hospitals to feel comfortable with high stocks. Hospitals are not willing to take

on the risk of these high value devices and will not assume the responsibility. The fast pace of technological change, relatively slow movement of stock, in combination with the high value of these devices, were listed as the major reasons why hospitals are not willing to buy these items and make them part of their basic stock holding.

Hospitals do not have the manpower to manage the inventory of these devices and regard this task as too labour intensive. There is no waiting time in this industry from a doctor's perspective and cases are rarely elective. Inventory, therefore, has to be available on the shelf as and when required.

In an environment where a customer's willingness to wait for a product is shorter than a specific product's production and delivery lead time, make-to-stock is the best solution to serve the market (Schrageheim & Burkhard, 2007). This is exactly the same principle that applies in the interventional cardiology sector. When a doctor has the patient on the operating table and has completed the diagnosis through performing an angiogram, the doctor makes a decision "on the spot" as to what product and size will be needed to provide the best solution to the patient. He instructs the cath lab staff member (generally the nurse) to draw the applicable product off the shelf. There is hence no waiting time and the product has to be available on the shelf. If a specific product is not available, a competitor's product will be used. It was clear from the interviews that multiple competitors' products are available on the shelf and that a patient very rarely will not be helped due to one supplier being out of stock. Suppliers, therefore, need to ensure that the right product mix is available on the shelf, should a doctor ask for a specific line item.

Vendor managed inventory (VMI) is a practice where suppliers are responsible for inventory levels at the point-of-sale location. In this industry, the point-of-sale location is in the cath lab. The supplier therefore makes the replenishment decisions, and downstream links do not have to carry the burden of managing inventory. Consignment stock management is the same as VMI, apart from the fact that inventory remains on the supplier's books. Write-offs will, for example, come straight off the supplier's bottom-line and not off that of the hospital. If the suppliers correctly manage this process, there should be an increase in stock turns at the downstream links as well as a reduction in stock outs (Battini et al., 2013). Nicholson, Vakharia and Erenguc (2004) claimed that outsourcing of inventory decisions in the healthcare industry has become current practice, especially in the form of consignment stock management solutions.

In conclusion, the findings show that consignment stock management is certainly best practice when managing inventory of interventional cardiology medical devices at hospitals. The findings do not only agree with the literature, but also add to the literature. Suppliers do not have much of a choice in the consignment stock management decision. All suppliers mentioned that consignment stock management is beneficial to the hospitals and all of them would have liked to move away if given the choice. All hospitals mentioned that the consignment process is cumbersome, but no other solutions currently exist. Hospitals are becoming increasingly more reluctant to carry the risk of inventory and it is becoming the supplier's responsibility (Nag et al., 2014). The consignment stock model is characterised as an arrangement where inventory is pushed downstream into the supply chain. Suppliers therefore need to size the buffers on consignment at hospitals carefully and find ways to react swiftly after end-user consumption has occurred.

6.4 Research Question 3: Is useful information effectively shared between hospitals and suppliers within the interventional cardiology medical devices industry?

From Tables 5.9 and 5.10, it was clear that useful information is effectively shared between supply chain links in the interventional cardiology industry. There is, however, room for significant improvement, which will help to streamline processes and inventory flow even further. The goal of information flow needs to be 'What must move to the next link today / tomorrow?'

Private hospitals timeously convey consumption signals to supply companies. The same cannot be said for the public hospital sector where communication is nearly non-existent; company representatives personally have to drive this process by ensuring that public hospitals are visited at least once a week.

Across all sectors, doctors are difficult to get hold of and this makes it hard for reps to get a feel for what product mix needs to be available on the shelf. Some doctors are brand loyal and others are not. It is, therefore, important for a supply company to build the right relationship with the doctors to firstly understand what products they need on the shelf. Secondly, a good relationship with the doctor seems to be directly related to positive sales volumes.

Zhang and Cheung (2011) claimed that information sharing amongst supply chain links is effective to streamline flow within a distribution system. Information sharing in this context refers predominantly to the exchange of demand and inventory information between upstream and downstream links. The transfer of real-time information is perceived to be the most effective mechanism to allow effective inventory flow. Sousa et al. (2012) promoted interaction and information integration with customers, which will naturally have a reduction effect on inventory levels. From the interviews, it was clear that none of the supply companies were electronically integrated with any of the hospitals. Consumption signals in general were communicated to suppliers within 24 hours after consumption of the products. Resources, time constraints and skills were listed as barriers to a timeous information flow. The Kanban concept explains the process of effective information flow through the use of a tag. This tag or card carries information about the inventory withdrawal, the transport process, and the product details (Matzka et al., 2012). The sooner this information can be transmitted to the supplier, the quicker replenishment can take place and the fewer inventories have to be carried within the system. Organisations need to stop operating in silos looking after their own self-interests; collaboration between supply chain links needs to be the order of the day. Information flow needs to cross organisational boundaries where all supply chain links are connected; that will result in a sustainable competitive advantage to all (Niezen & Weller, 2006)

The consignment stock management process is a one-sided approach where the supplier carries all the risk. From the interviews, it was clear that consignment stock management is solely the responsibility of the supply companies and more specifically the company reps. Stock counts have to be executed on a monthly basis as a minimum contractual requirement set by hospitals. If reps do not count their stock and make sure that such stock report is signed off by the hospital staff, the supply company will be held responsible in the event of stock discrepancies. It is therefore in the rep's own interest to count their stock as often as possible as missing stock will be deducted off their commission payments if stock is not counted at least once a month. No information flow occurs between the hospitals and the supply companies in terms of stock-on-hand data. The only time information flow occurs is when a product has been consumed and the hospital needs an invoice to bill and discharge the patient. Information needs to flow more freely between supply chain links in order to reduce waste of many forms in this industry. Information flow has a direct impact on inventory levels (Stavroulaki & Davis, 2010). Information sharing is one of the strongest mitigating factors to address the bullwhip phenomenon. Information sharing includes good quality

information to be exchanged on consumption, demand and point-of-sale data (Barros et al., 2013).

In conclusion, the findings show that useful information is effectively shared between hospitals and suppliers within the interventional cardiology medical devices industry, particularly between private hospitals and suppliers; there is, however, room for significant improvement. The findings agree with the literature. Stavroulaki and Davis (2010) emphasised the importance of close supplier-customer relationships where information is shared freely. It is of fundamental importance that consumption and inventory information gets transmitted on-time to the correct people within the supply chain. This will ensure that inventory moves at the right time and in the right quantities, answering the question 'What must move to the next link today / tomorrow?' (Lee et al., 2004).

6.5 Research Question 4: Is waste present within the supply chain of interventional cardiology medical devices?

From Tables 5.11 and 5.12, it is apparent that a significant amount of waste is present in this industry's supply chain, with inventory write-offs being the biggest contributor. Due to the nature of the consignment stock management model, where the whole range needs to be available on the shelf, stock write-offs will naturally occur if not actively managed. An enormous amount of inventory is written off in this industry each month. These write-offs have become a cost of doing business to all the interviewed supply companies. They admitted, however, that this is a major concern to their respective organisations and that their aim is to reduce write-offs as far as possible. Only recently have these companies started to find ways to curb write-offs through managing close-to-expiry stock better.

It is important for supply companies to break the assumption that high write-offs are a cost of doing business in this industry. This industry historically has enjoyed above average margins in order to make up for high levels of write-offs. It was clear from the study that medical aids are becoming stricter when it comes to pricing and this will have a direct impact on the various supply companies and their profit margins. Supply companies can, therefore, not continue to depend on their high profit margins and will need to become clever when managing their stock and ultimately the flow of inventory within this industry.

Other forms of waste identified were in-transit damages, incorrect stock opened by cath lab staff members and inventory going missing within hospitals. Hospital staff members mentioned that the consignment stock procedure is tedious and takes a significant amount of time and effort to manage successfully. Consignment contracts are rigid and take a lot of time to keep up to date. Return procedures to international DCs are complex and make it hard for supply companies to return non-moving stock to them. These identified forms of waste tie in with Taiichi Ohno's seven types of waste, which were stock on hand (inventory), overproduction, time on hand (waiting), transportation, movement, making of defective products, and processing itself (Ōno, 1988). By running a nimble supply chain, which only reacts on end-user consumption, many of these wastes can be eradicated. Supply chains need to focus on high inventory availability and need to be responsive to changes; the interventional cardiology industry is no different. The simulation exercise clearly showed the benefits of dynamic buffer management and swiftly reacting to end-user consumption through short lead times. Inventory reduction, increased availability and sales growth through reduced stock-outs were the main outcomes of the simulation that was based on real data gathered in the industry.

Kumar et al. (2013) highlighted that non-value-added activities are also forms of waste. Tedious consignment contract processes and time wasted trying to train an unwilling workforce are all good examples observed in the industry. An activity is only perceived to be valuable when a customer is willing to pay for it. Effective information sharing amongst supply chain links is an effective way to reduce waste in the interventional cardiology supply chain (Stavrulaki & Davis, 2010). Barros et al. (2013) argued that waste results in exponential inventory increases and increased lead times across the supply chain. From the interviews, it was clear that both high inventories as well as slightly unpredictable lead times from international suppliers are present in the various supply chains of the interviewed supply companies and hospitals, proof that waste does exist in these supply chains.

In conclusion, the findings show that many forms of waste were found to be present within the supply chain of interventional cardiology medical devices. The findings agree with the literature. A positive aspect is that devices are of great quality and product defects are rarely encountered. Ōno (1988) stated that eliminating forms of waste in a supply chain can improve the operating efficiency by a large margin. Operating efficiency is the difference between an organisation's inputs and outputs. The ultimate result will be an increase in net profits across the chain. Seeing that obsolescence and ultimately write-offs are the biggest form of waste present in the

interventional cardiology industry, suppliers need to guard against pushing product onto downstream supply chain links and should rather follow a dynamic buffer management model to stock management.

By following these TOC principles closely, the level of inventory will automatically drop as the supply chain will have the ability to rapidly respond to customer demand. Stock should therefore not be pushed onto downstream links, but dynamic buffers need to be calculated based on end-user consumption. Surpluses and shortages will automatically be eliminated when local efficiencies are abolished and whole system thinking processes are adopted (Goldratt, 2009).

6.6 Discussion of the Simulation Exercise Results

The simulation exercise produced interesting results as presented in the previous chapter. It helped to identify gaps between the simulated state and that of the current state (status quo). These gaps helped to compare current practice activities with best practice methods that were, amongst others, frequent replenishment tasks in line with end-user consumption. The simulation exercise clearly helped to demonstrate where inventory and distribution operations within a firm can be improved, realigning the supply chain based on end-user demand. Improvements generally resulted in lower levels of inventory across the supply chain with reduced occurrences of stock-outs. These improvements resulted in increased levels of customer service, significant cost savings due to reduced write-offs and ultimately improved levels of profitability (Janse van Rensburg, 2014).

When placing the initial buffer of inventory on consignment, interventional cardiology supply companies will need to make an accurate prediction of the level of sales that can be expected. One can describe this as an 'accurate best shot in the dark'. From there onwards, dynamic buffer management will provide the supply company with an indication to increase or decrease those buffers. Following these principles, planning will become demand driven opposed to building stock based on forecasts. Actual usage will consequently dictate what flows within the supply chain.

For the supply companies that only keep stock on consignment and none in their regional warehouses, they lose the advantage of aggregation as they drive local optimisation opposed to whole systems thinking. According to Barros et al. (2013), the various systems need to be viewed as a whole should these supply chains attempt to

achieve superior performance. These supply chains should be managed in a holistic manner opposed to each supply chain link trying to look only after their own interests.

It was clear from the interviews as well as from the simulation exercise that certain sizes of devices move a lot faster than others. This complex environment makes it difficult to manage each SKU and forecasts are not accurate enough to successfully manage inventory buffers and other triggers for flow in this industry. That is why Symphony software is a tool that can be used to bring buffer levels on consignment down to acceptable levels. Thereafter, flow will only be triggered by end-user consumption. The attractiveness of Symphony is that buffers will be adjusted as time goes by, ensuring that buffers are increased when end-user consumption rises and will decrease should demand decline. This will keep write-offs to a minimum and ensure the availability of inventory at the right locations, ultimately increasing profitability and shareholder value.

6.7 Chapter Summary

This study aimed to evaluate whether end-user consumption is used as the trigger for flow of interventional cardiology medical devices. Supply companies and hospitals both agree that end-user consumption is not used to build the buffers of inventory kept on consignment in the cath labs, but that they are calculated based on forecasts. All participants, however, agree that – after the buffers have been built and consumption occurred from those buffers – replenishment is done based only on end-user consumption.

All participants agreed that consignment stock management is best practice when managing inventory of interventional cardiology medical devices. There was furthermore good evidence that effective information flow does occur within this industry, particularly from private hospitals, but there is room for significant improvement; supply chain links need to find ways to integrate their systems. A significant amount of waste is present within this supply chain with write-offs being the biggest contributor.

CHAPTER 7: CONCLUSION

7.1 Introduction

This chapter aims to provide an overview of the study and to provide evidence that the objectives of the study were achieved. The main findings of the study are discussed and recommendations to the major stakeholders within the interventional cardiology medical device industry are presented. Limitations of the research as well as suggestions for future research are discussed. The chapter closes with a conclusion, which highlights the importance and value of the research in the light of the findings.

7.2 Overview

The aim of the study was to understand the end-user's consumption patterns, and whether end-user consumption was used as the only trigger for flow of interventional cardiology medical devices. The study further aimed to look for answers around whether consignment stock management is best practice in this industry, whether useful information is effectively shared between the supply chain links, and searched for forms of waste possibly present within this industry. All research questions were answered successfully and the objectives of the study were achieved.

A dynamic buffer management (DBM) simulation exercise was performed, using specialised modelling software currently available in the marketplace. Primary data provided by one of the supply companies were used in the simulation exercise. The simulation, therefore, was used to serve as a process of triangulation to confirm whether the interview data was aligned with the findings from the simulation exercise, which added to the study's robustness. Both elements, the interview process as well as the simulation exercise, added to and confirmed academic and business knowledge as set out as an objective in Chapter 1.

A multiple-case study approach was pursued, whereby four leading suppliers within the industry were interviewed as well as the end-users of interventional cardiology medical devices in the form of four different hospitals within the same supply chain. According to Gerring (2006), this form of research is called a comparative method case study design.

7.3 Main Findings

The core problem identified was that inventory in general is pushed onto downstream supply chain links and that goods flow as a result of a forecast. The effect is that downstream links are often overstocked and the whole system is slow to react to end-user pull. Excessive stock at hospital level leads to undesirable write-offs as stock becomes obsolete. Buffers are sized originally from forecasts, which are based on past sales and expected future sales levels. According to TOC, for the buffer to reflect reality, dynamic buffer management needs to be applied, which does not utilise forecasts anymore. The target level needs to be carefully calculated, as it was found that too high levels of inventory were often carried in the cath labs, an indication that replenishment to buffers happens when there is no real need to do so (Cox III & Schleier, 2010). End-user consumption is not used to build inventory buffers at cath labs.

Clear evidence was found that supply companies only replace consignment stock after receiving the consumption signals from the hospitals. Private hospitals are very diligent in sending the consumption signals to the supply companies, as they cannot bill their patients if the supply companies have not yet invoiced them for the devices used on consignment. The same cannot be said for the public sector, where signals rarely get communicated to supply companies. Pull signals trigger the flow of inventory and the consignment buffers are usually restored within a day or two after receiving the signals from the hospitals. Suppliers do not seem to invest much time on establishing whether a device really has to be replaced; a replenishment device is nearly always sent after consumption has taken place. Zhang and Cheung (2011) stated that – to a large extent – supply chain management is both a science and an art that together aim at precisely matching supply with demand. End-user consumption is used as the trigger for flow after a device is used in the cath lab.

All participants agreed unanimously that consignment stock management of interventional cardiology medical devices is the only sales process currently dominating the industry. They also could not see a workable alternative available to them and that consignment stock management will dominate this industry for a long time to come. The main reason for this is that hospitals are unwilling to assume the responsibility for these high value stock items. The fast pace of technological change, the relatively slow movement of stock as well as the labour intensive stock management these devices require were listed as more reasons why this model will not change. Nicholson, Vakharia and Erenguc (2004) claimed that outsourcing of inventory

decisions in the healthcare industry has become current practice, especially in the form of consignment stock management solutions. Consignment stock management is certainly best practice when managing inventory of interventional cardiology medical devices at hospitals. Suppliers therefore need to size the buffers on consignment at hospitals carefully and find ways to react swiftly after end-user consumption has occurred.

It was clear that useful information is shared effectively between supply chain links in the interventional cardiology industry. The goal of information flow needs to be 'What must move to the next link today / tomorrow?' There is, however, room for significant improvement, which will help to streamline processes and inventory flow even further. None of the hospitals are electronically integrated with any of the interventional cardiology device suppliers. OrderWise is a web-based system currently being used in an attempt to simplify the ordering system, but does not connect supply chain links seamlessly. The system is very dependent on staff intervention. In most cases, the consumption signal is sent via e-mail from hospital inventory controllers to assigned customer service employees at the suppliers. These signals, coming from private hospitals, reach the suppliers in most cases within 24 hours after consumption has taken place. Zhang and Cheung (2011) claimed that information sharing amongst supply chain links has to be effective to streamline flow within a distribution system. The transfer of real-time information is perceived to be the most effective mechanism to allow effective inventory flow.

It is apparent that a significant amount of waste is present in the interventional cardiology medical device industry's supply chain, with inventory write-offs being the biggest contributor. Even though write-offs have become a cost of doing business to all the interviewed supply companies, only recently have they started to find new ways to curb write-offs through managing close-to-expiry stock better. In an environment where profit margins are shrinking, supply companies need to become more innovative when managing their stock and ultimately the flow of inventory within this industry. Stock damaged in transit and hospital staff members opening the wrong products are some forms of waste present in this supply chain. Kumar et al. (2013) highlighted that non-value-added activities are also forms of waste. Examples of these are tedious consignment contract processes and time wasted trying to train an unwilling workforce. Ōno (1988) stated that eliminating forms of waste in a supply chain can improve the operating efficiency by a large margin.

In conclusion, overwhelming evidence exists, demonstrating that end-user consumption is used as the trigger for flow of interventional cardiology medical devices placed on consignment at hospitals. Replenishment of inventory on consignment was performed to daily pull. However, the core problem is that goods still flow mostly as a result of a forecast. Considerable potential exists to improve flow through the use of a dynamic buffer management approach. Consignment stock management is the only workable solution for the time being and information flow from specifically the private sector is up to standard. Electronic and more automated information flow will improve the communication channels even further. Significant forms of waste were found to be present within this industry, especially high amounts of inventory write-offs present within the system.

7.4 Recommendations to Stakeholders

Although to supply companies it may seem that consignment stock management is the only means to serve this market, supply companies can still find innovative ways to approach hospitals in order to entice them to buy stock opposed to following the consignment stock management route. Hospitals will be easier to convince where large volumes of specific items are being consumed. An alternative example will be to offer combo deals to the hospitals or to provide them with relief on shelf life. If for example, a hospital agrees to buy a hundred units and only returns five, the penetration rate is still much higher than any consignment model elsewhere. These offerings need to form part of a supply company's strategy as to how the market is approached.

An interesting and profound observation was made in that all hospitals were more concerned about the invoice for the consumed device to be sent to them on time, and were not as much concerned about receiving a replacement item. This breaks the assumption that an invoice should always be accompanied by a replacement device to the hospital. This shows that supply companies mainly replace products in order to prevent the doctor from using the competitor's product and out of fear that they might run out of stock on the shelf. If companies, therefore, calculate their buffers more carefully and only replenish an item that really needs to be replenished according to dynamic buffer management methodologies, they will achieve superior stock levels compared to supply companies that do not employ the same thinking. Before stock is replenished, thorough analysis needs to be done and should not be seen as a task that needs to occur automatically.

Something supply companies can consider is to guarantee hospitals 100% stock availability and that they would be willing to pay penalties should they not keep to their promises. The condition, however, needs to be that the hospitals need to send the signal through within a couple of hours after consumption has taken place. Supply companies can ask hospitals to measure their product availability, replenishment speed and other key performance areas. Offering such arrangements will assist supply companies to increase market share within this highly competitive environment. These partnerships, which guarantee remarkable availability coupled with reduced inventories, can provide supply companies with a decisive competitive edge over their competitors and is called mafia offers (Cox III & Schleier, 2010). Supply chain performance is an incredibly powerful marketing mechanism.

The drive towards electronic data interchange (EDI) is another option that can be followed in order to streamline the replenishment process even further as it promotes effective information sharing between supply chain links. If hospitals integrate with suppliers, it will increase the flow of information between these links and will hold advantages for both parties. This will assist suppliers to receive consumption signals faster upon which they will be able to replenish sooner. Fewer inventories will be needed across the whole supply chain.

Consumption signals from public hospitals are nearly non-existent. If supply companies aim to serve the public sector well, their representatives need to be able to establish good relationships with their counterparts at those hospitals. The public sector is very rep reliant. Representatives will need to visit the public hospitals on a near-daily basis and need to be willing to assist public hospital staff members to walk through the various administration processes. Supply companies need to be willing to invest in public-private partnership (PPP) business ventures and supply public hospitals with equipment needed to simplify the process of getting the consumption signal to the suppliers. An example will be the supply of scanning and e-mailing equipment. It will also be essential that supplier reps regularly conduct stock-takes, as these are part of their contracts with public hospitals.

7.5 Limitations of the Research

Subjectivity and bias had to be guarded against. Potential personal bias had to be avoided to be able to be as receptive as possible, to gain new insights and draw new conclusions.

South African Medical Device Industry Association (SAMED) members are not the entire universe of medical device companies within South Africa. SAMED members do, however, cover the majority. The research sample, therefore, will be limited as a representation of the SAMED population; the rest of the universe was excluded.

The study only focused on one specific private hospital group within the private hospital sector in South Africa. Having a catheterisation laboratory qualified a facility as a potential member of the population. The study did not focus on public hospitals, but many of the participants, however, referred to the public sector and results were recorded accordingly. The majority of catheterisation laboratories within South Africa are found within private hospitals.

Triangulation does not always provide final confirmation of a study's results; further detailed investigation on the topic therefore might be required (Saunders & Lewis, 2012). Due to the sensitivity of the primary data, only one supply company's data was used in the dynamic buffer management simulation process. Although the interview data aligned with the findings from the simulation exercise, using only one company's primary data can be seen as a limitation.

7.6 Suggestions for Future Research

Four supply companies participated in the study. Combined, they hold more than eighty percent of the total market currently served in South Africa. Interviews with other supply companies could have added to additional insights and this is a suggestion for future research.

Due to time constraints and the difficulty of obtaining ethical clearance from hospital groups in the industry, all four participating hospitals belonged to one of South Africa's major private hospital groups. Although data saturation was obtained after interviewing the eight hospital staff members, additional interviews with other private hospital groups could have added to the results of this study.

Although many of the case study participants referred to the public hospital sector in South Africa, future research can be conducted that focuses solely on the public sector and all the intricacies around the public sector. The public sector is often more prone to purchasing stock than keeping it on consignment. Studying the public sector might evolve to an interesting future study.

Consignment stock management is not used exclusively in the healthcare industry. Similar studies can be replicated looking at different industries. Principle findings from this study potentially can be tested across industries.

The role of company representatives was highlighted quite often in the various interviews with hospital staff as well as supply company staff members; the same study can be replicated in future from a company representative point of view.

It was clear from the interviews that medical aid firms are a force in the healthcare industry as they possess increasingly more power overtime. Future research can focus on the specific role that medical aids play in the decision-making processes of cardiologists in this industry.

7.7 Conclusion

The central focus of this study was to investigate the triggers for flow of inventory in the interventional cardiology medical device industry. This study helped to contribute to the understanding of inventory flow in the interventional cardiology medical device industry and surfaced valuable findings not only for the healthcare industry, but also in other sectors with similar stock management practices.

The findings that were established on information flow and elements of waste present within this industry hold a potential for further application across a variety of industries. Further research can build on these findings in order to establish if the same findings are true in sectors other than the healthcare industry. The theory of constraints thinking processes, which looked at cause-and-effect logic, helped to establish a solid foundation to this study. Dynamic buffer management practices and the intricacies around it need to be explored further through future studies and practical application.

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Appendix 1: Interview guidelines / questions – Supply Companies

1. Please will you provide me with a detailed description of your company's supply chain operations? Specifically pertaining to interventional cardiology medical devices (stents, balloon, catheters, etc. used in Cath Labs around the country)

Guiding Questions:

2. Does your company have an EDI link with the various cath labs? What ERP system is your company using? How is the consumption signal communicated to you?
3. How long does it take for a pull signal from the hospital to reach you? Are there ever delays? If so, how long?
4. After receiving the signal from the customer, do you ever experience internal delays before consumption data is loaded onto your own system?
5. Does your company import its devices from overseas? If so, please provide me with information around lead times and minimum order quantities. How often are orders placed on vendors and dispatched from them? How often are goods dispatched from overseas?
6. Does your company manufacture devices locally? If so, please provide me with information around lead times and minimum order quantities. How reliable are these lead times?
7. Does your supply company only supply on your request? Are these movements based on pull signals or are they pushed into your warehouse / customers?
8. On a scale from 1 to 5, how would you rate the reliability of your inbound supply chain? (1 being worst and 5 outstanding)
9. On a scale from 1 to 5, how would you rate the reliability of your outbound supply chain? (1 being worst and 5 outstanding)

10. How nimble is your supply chain? How swiftly can you respond to customer requests / emergency orders?
11. What are the lead times to your customers from your central hub / 3PL?
12. Who within your company is responsible for demand forecasting? How are these forecasts utilised in terms of purchasing of goods?
13. What is the company's policy around safety stock buffers? How are these buffers calculated / sized in your warehouse as well as at the cath labs?
14. Is flow triggered by end-user consumption or is product "pushed" into the market based on sales forecasts?
15. How erratic are sales / pull from the market?
16. How many cath labs across South Africa does your company supply to?
17. Is the bulk of your consumption coming from the public or private sector? Percentage split?
18. How do supply chain operations differ between the public and private sector?
19. Are all private sector customers' supply chains uniform? If not, please explain.
20. Do the cath labs dictate needed quantities to be on hand at all times or do you (the supplier) decide?
21. Do you feel there is conflict between the cath lab's requirement to hold ample stock versus your attempt to keep stock levels and ultimately write-offs as low as possible?
22. Is there an effective mechanism in place to rotate stock within the market? Does rotation of stock often occur? If so, who drives this to ensure it gets done?
23. Please give me an overview of your company's stock obsolescence situation.

24. What are your annual write-offs as a % of sales?
25. To what degree do you believe waste is present in this supply chain?
26. How do you ensure stock level accuracy on a monthly basis?
27. Do you use external companies to manage your stock counts?
28. How important is the relationship between the rep / doctor / cath lab nurse?
29. Which factors influence a doctor's decision to choose between suppliers?
30. Do you believe that consignment stock / VMI is best practice? What are the alternatives / your future view?
31. What is your inventory coverage in weeks / stock turn? What is the market average?
32. Do you often lose sales due to stock-out situations? Please explain.
33. Do you believe that your company only supplies after receiving a pull signal?
34. Do medical aids govern which products / suppliers have to be used?
35. Any additional comments you would like to add?

Appendix 2: Interview guidelines / questions – Hospitals

1. Please will you provide me with a detailed overview of this cath lab's supply chain operations? Specifically pertaining to interventional cardiology medical devices (stents, balloon, catheters, etc.)

Guiding Questions:

2. How many cases are performed on average per month in this lab?
3. Does this lab have an EDI link with suppliers? What ERP system does this lab use?
4. Does this lab own any of the medical devices or is it all consignment stock? % split?
5. Do you believe that consignment stock management / vendor managed inventory (VMI) is best practice? What are the alternatives?
6. How soon is the supplier informed after a medical device with you on consignment has been used? Are there sometimes delays? If yes, how long?
7. What mechanism is used to communicate consumption as well as demand to suppliers?
8. Do you order fresh stock based on reorder levels or what triggers a new order from the supplier?
9. Is preference given to specific suppliers when procedures are performed or how do the criteria to consume work? What factors influence doctor's preferences?
10. Can the cardiologist wait for a device to be shipped to him or does he need it to be immediately available upon request?
11. Are urgent shipments effectively expedited to you?
12. How reliable are suppliers' lead times?

13. Does this catheterisation laboratory use RFID (Radio Frequency Identification) or any other stock control technologies? If not, are there future plans to implement such technologies?
14. Who is responsible for stock accuracy? May suppliers use an external company to manage their stock counts?
15. What amount of product reach expiry whilst with you on consignment? Would you say obsolescence and other forms of waste are a problem in this specific supply chain?
16. Are suppliers informed as and when products reach their expiry dates / getting close to expiry?
17. Would you say that catheterisation laboratories are in general overstocked / understocked? Do you have target stock levels to maintain? Who decides on this?
18. What is the inventory coverage in this lab? Value (stock keeping & consignment). Stock days target for the hospital in general?
19. Does stock management enjoy top priority in this lab?
20. Do you ever have stock-out situations? What do you do in such instances?
21. Would you say that you only receive fresh stock as and when there was consumption within the lab? Do you believe that flow only happens after a customer pull has taken place?
22. What other major challenges do you experience in this supply chain?
23. Do you see a different future for the cath lab / medical device industry?

Appendix 3: Codebook

Code description	Number of occurrences
Supply chain waste	70
Company representative responsibilities	58
Cardiologist and technical team preferences	48
Inventory management	47
Consignment stock buffer management	42
End-user pull signals	41
Consignment decisions	31
Stock counts	23
Role of the medical aid	22
Medical procedure information	22
Consignment consumption process	21
Consignment contract	19
Public sector operations	17
Interventional cardiology market environment	16
Product listing process	15
Stock rotations	15
Hospital formulary guidelines	13
Cath lab operations	12
Delivery process	10
Patient billing process	10

Appendix 4: Informed consent letter

TITLE OF THE STUDY:

Evaluating whether end-user consumption is used as the trigger for flow of interventional cardiology medical devices

Health Science Ethics Committee (University of Pretoria)

PARTICIPANT'S INFORMATION CONSENT DOCUMENT FOR INTERVIEWS WHERE INFORMATION SUPPLIED WILL BE KEPT ANONYMOUS

Dear Participant,

I am a second year student studying towards an MBA at the Gordon Institute of Business Sciences. This degree covers general management practices in the Department of Business Sciences, University of Pretoria. You are invited to volunteer to participate in my research project on **evaluating whether end-user consumption is used as the trigger for flow of interventional cardiology medical devices**.

This letter gives information to help you to decide if you want to take part in this study. Before you agree, you should understand fully what is involved. If you do not understand the information or have any other questions, do not hesitate to ask me. You should not agree to take part unless you are completely happy about what I expect of you.

The purpose of the study is to evaluate the triggers for flow of interventional cardiology medical devices and to understand the supply chain of these devices better. I would like you to participate in an interview, which may take about one hour. I will personally conduct the interview. Interview data will be kept in a safe place to ensure confidentiality. The interview will be audio recorded and sent for transcription.

The aim of the interview will be to keep questions general; should you, however, feel that certain questions are sensitive; you need not answer questions that are of a sensitive nature to you.

The Research Ethics Committee of the University of Pretoria, Faculty of Health Sciences, can be contacted on telephone numbers 012 3541677 / 012 3541330.

Your participation in this study is voluntary. You can refuse to participate or stop at any time without giving any reason. As mentioned, information supplied will be kept anonymous. Once the interview has been conducted, you cannot recall your consent. The information supplied by you will, however, not be traceable. Therefore, you will also not be identified as a participant in any publication that comes from this study.

In the event of questions asked, which cause emotional distress, the researcher will be able to refer you to a competent counsellor.

Note: The implication of completing this form is that informed consent has been obtained from you. Thus, any information derived from the planned interview (which results will be kept totally anonymous) may be used, e.g. publication, by the researcher.

If you have any concerns, please contact me or my supervisor. Our details are provided below.

Researcher: Andries van Rooyen

Email: andriesvr@gmail.com

Telephone: 084 584 0436

Research Supervisor: Philip Viljoen

Email: philip@toca.co.za

Phone: 082 651 5977

Signature of participant: _____

Name of participant: _____

Date: _____

Signature of researcher: _____

Date: _____

Appendix 5: Additional comments – Research Questions 1A and 1B

Supply Company Interviews

CASE A

Case A – Participant 1: “...in a consignment stock and replace environment, what you are invoicing has already been placed and been used so you just generate an invoice.”

Case A – Participant 2: “Supplier to us is also pull. They do not push anything onto us. We tell them what it is we need and obviously we have objectives that we need to achieve each year and so long as we fall within the objective, there is no discussion and if we cannot fall within that objective, then obviously we would have that discussion with them, but they do not push stock on us.”

Case A – Participant 1: “We do have a software package, which communicates with our accounting system and it gives you a suggested order.”

Case A – Participant 2: “Yes. But it is a suggested order. It does not say this is what you are going to order. So we will still put marketing intelligence and logistical intelligence into that decision.”

Interview question: What is your rationale in terms of your calculation of building that consignment buffer?

Case A – Participant 2: “... our product range, we have from very small to very big. Obviously, your fast-moving lines are your middle sizes where the balloon outliers do not move as quickly, so you try and keep four to six pieces of your fast-moving goods. But the outliers, you can never keep four to six because most of those are sitting there for months. But, the fast-moving goods, we are looking at four to six weeks’ buffer. Well, their consignment stock is their buffer. So, they have one of each and it is replenished. So there is no buffer per sé, one could argue that the fact that they have consignment is their buffer.”

Case A – Participant 2: “So we also have a buffer. We have our stock here in the warehouse, which is worked on what our average sales are to help us understand what we are going to replenish. But there is no buffer in the hospital other than the actual consignment stock. It depends on the account and what the size of their account is and how regularly they use something. So some accounts may only have one of each size, some faster-moving accounts might have two of the more common sizes, so it is possible that they could have a buffer, but it would really depend on the account if that makes sense.”

Case A – Participant 2: “Outlying areas like Bloemfontein and Eastern Cape are serviced pretty quick because the reps are doing it themselves. Those locations do, however, have extra buffer in there as delivery may take longer than a day or two. Reps sometimes do keep a very small amount with them also.”

Case A – Participant 1: “We nearly have around a year’s stock cover on hand, but again, the outliers throw you out.”

Case A – Participant 1: “But to answer that, we do not necessarily always have a buffer. Sometimes, as soon as we receive the stock we fill the back-orders and then have the item on back-order and we have to reorder. It depends on usage country-wide for a specific size.”

Interview question: Say a product gets consumed in a cath lab, how is the signal communicated to you?

Case A – Participant 1: “Making the assumption that stock is already on consignment, our consignment is sent with a delivery note so each item is consigned with a serial number and the size of that item that then gets placed on consignment. Consignment is a range in the cardiology environment; it is a range of products and a range of sizes so there are different permutations for whatever they may require. But, essentially, what it comes down to is the item is used in the cath lab and the trigger will be for them to place the order as per the delivery note.”

Case A – Participant 2: “Replenishment is driven by usage. And what happens is, they will phone or our rep will pick it up at the hospital or it will come through OrderWise. There are a number of ways they can do it, but the driver and the trigger to your question is the actual use on a patient.”

Interview question: Please provide me with information around lead times and minimum order quantities.

Case A – Participant 1: “We place orders once a month, so we look at the previous months’ consumption. We consider three months’ and six months’ usage. We have no minimum order quantities. You can order one item or sometimes up to a ton of stock. It all comes express. Lead times, usually, provided that they are not on back-order, within a week because we bring it in express. So an order is sent through, it is usually confirmed same day and we need to confirm expiry dates. If that happens the same day, they usually pick and pack and send by the next day. And then, with express it takes about three days, so we are looking at five days.

Case A – Participant 2: “Well, we plan to order once a month. It does not always happen that way. Sometimes you have top up orders as well during the course of the month. Primarily, what we look to do is to place one order because obviously express is not cheap, so you try to reduce the amount of courier costs that you have.”

Case A – Participant 2: “It also depends on usage. You can never be sure what is going to be used or what is not going to be used and your stock levels, as much as they are a guesstimate science, they are never going to be 100%. So there are always anomalies that come up and we might have to expedite back-orders and sometimes they do not have stock, which then puts you under pressure here.”

Interview question: How erratic is sales pull from the market in general?

Case A – Participant 2: “Well, when you are talking about erratic you need to define that because it is dependent on demand. Do we have cycles? Yes, we have cycles. Are those cycles really measurable? Yes, to a degree, but I think it is pretty consistent. I do not think it is that erratic because you have the doctors that are pulling in patients and heart disease is on the increase, so I do not think there is an erratic flow of product.”

Interview question: Do you feel there is a conflict between the cath labs’ requirement to hold ample stock versus your attempt to keep stock levels and ultimately write-off as low as possible?

Case A – Participant 2: “Without question. Look, the cath lab sister’s job is to make sure the doctor has what he needs when he needs it. That is her job. Our job is to make sure that he has what he needs when he needs it, but at a level. The difference between the two concepts is that we are looking to optimise it and she is looking at just having it. And there is a huge difference between those two objectives. Some doctors are, shall we say, slightly temperamental and we know that nursing staff are being fired as a result of doctors, so they are not going to do things that are going to irritate them.”

Interview question: Do you believe that your company only supplies after receiving a pull signal?

Case A – Participant 2: “Yes, always.”

CASE B

Case B – Participant 1: “...in the product box there are product stickers and those stickers will go onto the patient’s sheet, so as devices on consignment are used for that patient, they peel off the sticker and put it onto the patient’s sheet. They will then say, OK, we have used a guide wire, a diagnostic catheter, a drug eluting stent, etc., all that goes onto the patient form and that goes to the stock controller, who in turn order replacements or request an invoice depending which company’s products have been used and it could be three to four different companies. Hospitals need the invoices as quickly as possible because the hospital got to bill the patient. The person at the supply company will invoice those devices out of the consignment stock and that should be the trigger that says we now have to replace it.”

Case B – Participant 1: “...the hospital places an order to invoice, so that is the deal concluded. But we want to make sure that in case the next patient comes in and needs that same size, that it is available and therefore is our trigger to replace that consignment stock item. So we only invoice what was on the shelf, but that in itself is the trigger that says replace the item immediately. So we will then place a fill order to have it replaced, the hospital does not ask for that replacement.”

Case B – Participant 1: “Cath labs do not care if you put extra stock on consignment. Some suppliers flood certain cath labs with their products, placing four to five devices of each size.”

Case B – Participant 2: “Product use is doctor specific. He might go on leave and no product is used, upon his return consumption picks up quickly. This is a challenging business model.”

Case B – Participant 2: “...big firms stock the labs properly with large volumes, but then put a lot of pressure on their sales staff to make the necessary sales.”

Case B – Participant 2: “In South Africa, doctors are actually running their own businesses; they thus get billed theatre time for say from 08h00 till 12h00. In that time, they have a list of say ten cases, so everything has to happen snappy. There is thus an unwillingness to wait for a specific product, if supplier A is out of stock, he will use supplier B’s product. Doctors thus have to work as efficiently as possible. Overseas it is different, seeing that it is the hospital’s time, but processes are surprisingly more efficient than here in South Africa. In South Africa, it is the doctor’s own identity, the doctor does not buy a single thing and the hospitals are saying it is the doctor’s choice. If it was not like that and the hospitals dictated, royalties would have been out the window.”

Case B – Participant 2: “After the stent or another device has been used, a reorder is triggered. The supplier automatically knows that one stent has been used at a particular hospital and that it needs to be replaced. The supplier checks whether there is availability and replenishes the stock which has been used. This should happen within 72 hours, that is the supplier’s commitment to hospitals and if items are not available, which need to be reordered from international suppliers and they generally take longer than 72 hours. The supplier therefore needs to make sure that all their products are available in the main local warehouse. If not, the hospital has a problem as they will have to wait. Hospitals will generally use the competitor’s product. If a supplier is constantly out of stock, they will get kicked out of the hospital, or they just ignore and neglect you.”

Case B – Participant 2: “In order to plan your stock level, you will ask the doctor how many interventions he generally does in a week, you also need to check how many supply companies are there already. If you are the sole supplier and he is going to do four lists a week, your stock levels will be higher. But if you know there are three supply companies on the shelf he might give everyone a turn so you will adjust your stock levels accordingly. It is unfortunately a bit of a learning curve, especially if you start with a new client, you will then have to see how he responds to your products. So you start with a very basic stock configuration and then take it from there. A big challenge is the consignment configuration and keeping the right product mix. Firstly,

do you have enough on the shelf and secondly, you need to make sure that you are not overstocked.”

Case B – Participant 2: “For me, the consumption signal is a concern, but also something, which I follow up on regularly. If the hospital does not report immediately that a certain product has been used, it automatically delays the whole process. If they use it today and tomorrow is a weekend plus say another public holiday, there three to four days are already lost. So we are out of the 72 hours benchmark. If they send it through late in the day, the ladies in customer services leave at 16h00, there I lose another day. If the ladies have too much work to do, the processing might be delayed with another day. So this whole entire workflow needs to be analysed from time to time and if there is a delay, it needs to be evaluated in order to establish what the reasons are for it. We try and streamline the process as far as possible, in the cases where reps are in theatre, we always instruct them to report immediately to our colleagues in customer services to notify them what has been used. So now they can already prepare the invoice for devices used. Along with the invoice comes a replacement order, the longer this takes the longer it takes for fresh stock to arrive from overseas, and that could damage our business. For the hospitals it is not as big an issue as it is for us, invoicing however has to happen by the time the patient gets discharged from the hospital. Sometimes, patients stay three to four days in the hospital, hospital staff members also sometimes forget, there are power failures, etc., thus so many obstacles. That is why reps need to communicate consumption as soon as possible, customer services will then just wait for the official communication from the clients and if there is none they will follow up. That is why there has to be a buffer in the warehouse to refill immediately...but the company often does not look favourably at these safety levels.”

Case B – Participant 2: “Hospitals and suppliers have conflicting interests. Hospitals want as much stock as possible on the shelf and suppliers as little as possible.”

Case B – Participant 1: “Forecasting is a shared function between the reps, product management and supply chain staff members.”

Case B – Participant 2: “...the consumption signal is identical across the private hospital groups; certain private hospitals on their side have a system called OrderWise, which is their ordering and procurement system. As long as the product is loaded on OrderWise and the pricing is right as well as the NAPPI code, the signal comes through.”

Interview question: Who calculates and agrees on the initial buffer at the hospital?:

Case B – Participant 1: “...the rep goes into discussion with the doctor, for example – Doctor, what is your view on this disease and the use of that device? He might say: It makes sense; I will use it in this list of diseases, but not for general main branch lesions, etc. Rep will then say fine, let me agree that we are going to put in this range of sizes. And then the rep has to push the doctor saying: doc, the inventory is there for you, use it. So the buffer is placed by mutual agreement. Another example: I will speak with a doctor and tell him that I would like to support him with inventory and what does he reckon. He then said: in the smaller sizes, put two of each size in each lab. Other doctors will say I want this this and that and I do not need those etc., supply me with those sizes and I will use them. Other doctors say I will support you but we are just not seeing the patients. In the Natal area for example there is proportionately more small sizes used due to the high instances of diabetes amongst the Indian population, and there it is critical to treat small vessel disease to ensure there is proper circulation.”

Case B – Participant 1: “...there has to be a buffer of stock in our central warehouse to support our top movers...”

Interview question: Is stock unnecessarily pushed into the market?

Case B – Participant 1: “We place a minimum level on consignment and then replace, unless if there are adjustments needed for example where there are two cath labs in one hospital, where doctors commit to higher usage etc.”

Interview question: Do you need at least two of each size on consignment in case one malfunctions?

Case B – Participant 1: “No, in all the years that I have been with the company and marketing devices we have had one product complaint. In the slower labs, one of each is fine. It may happen on the odd occasion where the doctor will use one the one day and does an angiogram the next day and needed that same size and we lost the sale, but they are few and far between.”

Interview question: What is your policy around safety stock?

Case B – Participant 1: “Well we do not really have any safety stock; it is all from source to cath lab, there is no safety stock. And as I have mentioned, it may be worth it to put some buffer stock in on the major sizes.”

Interview question: What will trigger you pulling out from a customer?

Case B – Participant 1: “If a doctor does not like your products, he perhaps had complications with your product. Competitor products are perhaps of better quality and superior features. If a doctor has stopped using your product due to marketing and sales support offered by the competitor, for example, the doctor has been sent on a course to America and he is now only using one particular supplier’s product. If it is a price thing you will have to discuss price.”

CASE C

Case C – Participant 1: “In South Africa, consumption is dependent by doctor by day. Tomorrow he might not like your face and he will use a competitor’s product.”

Case C – Participant 1: “When doing stock planning, the rep will go sit with the stock controller in the hospital, and based on past sales they will decide what quantities they should keep on consignment in the lab. It is therefore a joint decision. I feel that the staff in the hospital always are over anxious and try to push the quantities up because they are scared that they might run out of product, but that is why the rep takes past sales with them so that they can see based on past sales, what they really should keep. They also negotiate what should be kept in the event of a new product. That information then comes back to our product manager, she then compiles a whole forecast for the country based on that feedback and that would then include consignment stock plus the sales going forward and she then communicates that to supply chain and they put that forecast in the system. Then, before we launch the products, we have to bring all that product into the country based on that forecast to ensure that when we launch, we are able to continue supply and we do not go straight into back order, and then we go about a planned launch at the various accounts, based on their forecasts, we get the stock placed on cons and we will then go ahead and launch.”

Case C – Participant 1: “The more stock the sisters and stock controllers can keep in the cath lab, the happier they are. But pharmacy want to drive down the product that they are holding because although they have not laid money out, they also understand and it is a risk to them if there are any damages to the stock. There are thus contrasting parties within the same hospital. Sisters and stock controllers always try to

push stock up to keep the doctors happy because if the product is not there, they face the doctor.”

Case C – Participant 1: “Stock levels do not always agree with original contracts but with implementation of the par levels they should get to a point where what has been agreed on should be there, that is the aim and the ideal. That list in the consignment contract changes on nearly a daily basis. The only time that we will not replenish is if stock was made available for a special case. So sometimes in our business we will conduct a workshop where we will bring a doctor to come do some training and a specific type of procedure and then we will arrange extra stock to go to that location for that day so whatever gets invoiced will not get replenished because that was additional stock. Additionally, what was not used comes back. If it was the location’s stock, it will be replaced. Supply chain and customer services will, of course, be informed accordingly. Rep will tell customer services when not to replace.”

Case C – Participant 1: “Cath labs keep more than enough stock as consignment...”

Case C – Participant 2: “We are currently looking at different models with push and pull strategies, where we push stock into the local warehouse and then push stock into hospitals to achieve a certain level. When product is used, it will retrigger replenishment of stock from the stock keeping warehouse back into the hospital but it might not trigger the next demand of that same size. We are looking at different strategies to improve on the whole consignment stock model. We look at calculating levels and implementing levels in consignment accounts based on stats and usage. There is a typical bell curve of high movers, consumed once every six weeks as well as and low usage products moving once every 10 months and to calculate outer range items. You however need to carry them all. We are therefore looking at statistical calculations and we call them par levels for our consignment stocks and the project is currently in process rolling it out from business to business. The challenge is the sheer complexity and time it takes to calculate those levels. We also look at certain regions in isolation and opposed to keeping the whole range in every hospital, we rather keep the stock in a central location central to that area in for example Johannesburg, Durban and Cape Town. A good example will be to keep a month’s worth of stock of every size of every range at these central locations and then pull stock on a case specific requirement on the day. Doing so, consignment stock will hopefully be reduced through keeping it centrally, only pushing it out on the day.”

Case C – Participant 2: “...auto replenishing of stock happens twice a week and that replenishment is triggered by the following factors – current stock levels, safety stock

requirements, supply lead times and some other factors, which are applied with regard to your risk of variances in your lead time and usage. Thus, a couple of parameters are built in, so of course there is this statistical element that drives this target level in the warehouse, but when it is a brand-new product introduction, we are solely dependent on sales' input in terms of what they are expecting to sell. If it is replacing a previous product range and we have some history that we can utilise saying OK, based on historical data and usage, we estimate we are going to use so much plus a certain percentage more, depending on circumstances. We therefore replenish in-line with suggested levels. On a quarterly basis, supply chain will sit with product managers and will review those levels. They will accept or override and apply their intelligence to change those levels.”

Case C – Participant 2: “So it is only when we get the request to invoice that we will replace. The exception is when a rep knows that a whole bunch of extra cases are lined up and they might phone upfront and say: ‘listen, you might not have received the orders for invoicing, but please send out the replacement stock in the meantime.’ – That happens very seldom. The trigger is the hospital sending us the order.”

Case C – Participant 3: “Our inventory coverage is between three and seven weeks. We are replenished from our international distribution centre twice weekly.”

CASE D

Case D – Participant 1: “...for government, we will push five onto the shelf because we know that the order for the one that was used will only come in three or four weeks, which is frustrating. But for private hospitals, the process is much more streamlined where you generally receive the signal on the same day. Customer services will process it and whatever we receive on a day, they will process and we will deliver before 10h00 the next day. So it is very efficient.”

Case D – Participant 1: “From a private hospital perspective, the signal comes in within a day. With that said, again, the interaction between our service team and the hospital in terms of consumption and ensuring that the signal is pushed across quickly and we can replace, for that to happen, both parties need to be on the ball. You will find that certain hospitals are particularly efficient and you will find other ones that are poor. And that is just the way that they manage their stock, unfortunately. In that case, the customer service supervisor will have the conversations with them and be fairly

honest and just explain to them that although it is not a case of 'we are picking at what you are doing, but please understand the consequences of how you are managing your stock at the moment. If you want next-day delivery and if you want to run a lean stockroom of our products, then we need the constant flow of information to ensure that we replace the next day and for things to run smoothly'. It is not uncommon to find that a hospital asks for short-term stock because someone has not placed the order for the consignment replacement, which is, again, we cannot really point fingers, but we understand why that is happening. It is poor consignment management from our point of view. In general, the signal is received within a day, so next-day deliveries are what we do."

Interview question: You have mentioned that the supply chain team governs what stock is kept at the hospitals. How often is that consignment buffer reassessed?

Case D – Participant 1: "So, to answer your question, let's say you will have normal consignment running and then you have new consignment requests. So, before it becomes mature consignment, you will have the start-off where they speak to the doctor, your account is opened, they again speak to the doctor, they speak to the business unit manager and they decide on what they are going to put forward. Considering that we will always have next-day delivery so there is no need to put three on the shelf if you know that we will replace the one that is used the next morning. Once it is used, it is replaced. And on a quarterly basis, we look at the entire consignment countrywide. Quarterly, you look at the stock levels by hospital, thus, stock on hand, sales for the past six months and how long it has been on the shelf. And then, based on that there is another algorithm, based on what you have used, this is what you should have on the shelf. And we have seen good results, but to be honest, the main driver for excess consignment is interventional cardiology and it is because the doctor expects a full range on the shelf. That is the bottom-line."

Interview question: Would you say this is a push or a pull?

Case D – Participant 1: "I suppose it can be a push, but I would rather say it is a pull because if the request stems from the hospital then they are motivating an increase in stock based on A, B or C, maybe another doctor joining, etc. We have had a few requests in the last month from a hospital in Durban where we have had good feedback from the rep, saying that they have had a conversation with the hospital, they are expecting the following, so we need to up our stock. No problem. We always

encourage the reps to send e-mails. It is a two-way conversation. If it is the one part trying to dominate the other, then it is never going to work.”

Interview question: How do you calculate the stock level in your Johannesburg (Tier 2) DC?

Case D – Participant 1: “Going back to our ERP system, you have your forecast and we replenish based on that forecast. So it is a month’s worth of stock plus 20-30% worth of safety stock should there be any spikes coming through. On a quarterly basis, I reevaluate all the safety stock settings based on what I see.”

Interview question: Keeping ten on the shelf, is that not also a competitive advantage even though you only sell three of the ten to have that presence on the shelf?

Case D – Participant 1: “Yes, definitely. When it comes to the stock controller’s share of mind, it is very important. Our products need to be centred, in reaching distance and in the stock controller’s line of sight. So when we launch new products, we push enormous amounts of quantity. We literally take up two shelves. You could just see our product. I think it is linked strategically to what you are doing. I think it depends on the marketing team and what they are ultimately trying to achieve. If it is just us pushing stock onto the shelves to create share of mind, it might not have the effect that you are looking for if it is not coupled to a specific marketing strategy. So, for new launches, sure but it needs to be pulled back afterwards, once you have made them aware of the launch.”

Interview question: Do you feel that there is a conflict between the cath lab’s requirement to hold ample stock versus your attempt to keep stock levels and ultimately write-offs as low as possible?

Case D – Participant 1: “Yes, definitely. Then it is all up to the rep to educate the cath lab staff members and to explain the consequences to them. To the stock controllers they might say: ‘I am going to sell one a month so let me just keep five for in case. We need to explain to them to relax; if there is consumption we will deliver the next morning. And unfortunately that is up to the reps to drive that with the customers.’”

Interview question: Do you believe that your company only supplies to your customers after receiving a pull signal from them?

Case D – Participant 1: “Yes, for mature consignment, definitely and even if it is a new launch and we are pushing stock out onto consignment, it is still based on historical consumption. So for mature consignment business it is definitely a pull.”

Appendix 6: Additional comments – Research Questions 1A and 1B

Hospital Interviews

CASE E

Case E – Participant 1: “When stock is used, it is the stock controller’s responsibility to fax or email the order to the supplier’s representative. The nurse will come to the store room and ask for a specific stent based on a certain procedure, or take the item and it is her responsibility to inform the stock controller that the item has been used.”

Case E – Participant 1: “There is a consignment book, which is placed in each theatre. The book has space for a patient’s sticker, invoice number, date, theatre nurse’s signature, description, quantity, item number, etc. It is the nurse’s responsibility when they take the stock to complete the document and place the consignment items’ stickers on there (lot number, expiry date, etc.), the sticker safeguards the nurse, should the data written be incorrect. She then gives that to the theatre stock controller. There is sometimes a delay between handover to the stock controller, for example in the event of back-to-back cases. Procedure is to go ask for the book twice daily. The theatre stock controller will then take that order and his book is a triplicate book – first page is faxed through to the company or scanned to e-mail, he will put a read receipt to ensure the supplier reads his e-mail, he has a list of all contacts at the suppliers. He also has more than one e-mail address for each supplier, the company then has 24 hours to send the hospital the invoice, but most of the time it takes up to 48 hours. It’s his responsibility to ensure the supplier gets the communication from him. If he has not received the invoice within a day, he needs to call the supplier and find out if they have received his order. Sometimes they have to resend the order. Our hospital group gives the supplier 48 hours to send the invoice through. If it takes longer, we will go onto the system and alert the supplying company. Head office will then be informed that the supplier is not compliant to their rule of 24 – 48 hours and a brief summary of actions taken will be supplied by the hospital. Supply manager will then assess if this supplier is problematic across the whole chain. A meeting and action plan from that company will then need to be put together, including a list of corrective measures. He will then double check price, patient details and so forth along with the sister who needs to sign, attach that invoice to the order and send that off to a clerk who sits in pharmacy. This clerk deals with receipts and billing. The clerk is not the same person receiving and billing out stock and the reason is for financial governance. She will receipt the invoice on the hospital’s system. If there is a

price difference between the invoice price and system price, it is her responsibility to do a price query, which goes off to head office. It could be their or the supplier's error and systems need to be updated accordingly. After all adjustments have been made and everyone is happy, she will receipt it on the system and the patient will then be billed. This of course causes a delay. It will then be sent off to case management where it is sent off to the medical aid. Case management sits in patient services; they have to compile everything and check all bills, procedures etc., sign it and send it off to the medical aid.

CASE F

Case F – Participant 2: “The supplier has two days after a patient has been discharged to invoice the hospital. Company's turnaround time is generally within eight hours. The supply companies have dedicated people looking after certain hospitals and we e-mail them directly. Orthopaedic is different, the reps take the set back to the company, assess what has been used and then match with what the hospital said they have used. But in cath lab we work off a lot and reference number, as well as a doctor's name and they are more than happy to bill us. A consumption signal in the form of an e-mail is sent to the supply companies within 24 hours after consumption. The cath lab's operation is like a heartbeat, busy and then quiet. Like on Mondays, the list only starts at 12h00, only two cases are done and they finish at 14h00. Nursing will then sign off, which items have been used and will give the details through to the stock controller and he emails it out on the same day. Some lists are bad and they book 10 – 15 patients a day, those signals are only sent the day after. All stents come with a sticker and nothing is written, we just stick them onto the order form, on the patient's charge sheet and that is the documentation, which is e-mailed to the suppliers. There are four to six stickers, the doctor also sticks one on his notes and takes it back to his rooms, one in the register and another on the patient's charge sheet. All data is then sent off for archiving should a product be recalled for some reason.”

Case F – Participant 2: “...when a product range is replaced, I think that the drug remains the same, but the deliverability is more advanced. Old ranges will be sent to government hospitals or downgraded to the low budget medical aids where stents cost around R5000.”

CASE G

Case G – Participant 1: “...if the supplier decides to keep fewer items on consignment, the whole consignment contract needs to be amended by means of an addendum. The whole contract needs to be re-signed. If additional inventory is placed on consignment and it was not signed for, the supplier becomes liable.”

Case G – Participant 1: “The cath lab nurses are in the cath lab daily. They know which theatre lists are coming and should they suspect that inventory is low, they will order additional stock.”

Case G – Participant 2: “Suppliers try to keep enough stock in order to keep the doctors happy.”

Appendix 7: Additional comments – Research Question 2

Supply Company Interviews

CASE A

Case A – Participant 2: “The reality is, the hospitals might realise if there is more stock, but they will not say anything. The minute there is less stock than what is on the agreement, you will know. They would rather have the stock because at the end of the day that sister wants to be able to service the doctor. It is like a long sequence of blackmail that occurs from doctor to nurse to rep.”

CASE B

Case B – Participant 1: “...we need to understand, historically industry created this monster of consignment stock in the cath labs. It became a rod for our backs. The consignment model is not very prevalent in the rest of the world. My guess is that there is around R250 million worth of consignment across South Africa.”

Case B – Participant 1: “...even if we went to the hospital groups and tell them that we are not going to do consignment stock, but we will discount our price to them, they will say they are not interested. The reason is because the next supplier will do it on consignment at a similar price to what we are offering it at. I do not foresee the consignment stock model ever being changed.”

Case B – Participant 2: “A big factor is that in South Africa, rooms are rented out to the doctors. They therefore take on the risk and responsibilities and the doctor will thus be sued if anything goes wrong, not the hospital. In other countries it differs where doctors are covered by hospitals and hospitals compete with each other in order to attract the best doctors. Better treatment means better reputation, and that attracts more patients. Doctors like to make their own choices and therefore make the rules around which products they want to use, that they want it on consignment. Now, the hospital is not investing in stock and doctors neither, thus the supplier needs to make his stock available. In other countries it might differ where doctors do not have the choice as they work for the hospital and need to use the stock that the hospital purchases, there the hospitals have more purchasing power as they will demand discounts on volume and exclusivity. In South Africa it is different, here the customer who is the doctor, is king.”

Case B – Participant 2: “In South Africa, doctors want suppliers to look after them and they like to have a variety of suppliers to choose from. If Company A cannot fund my congress in the USA, then Company B will be willing. Now, from an ethical point of view, is it legal?”

Case B – Participant 2: “In the cath lab there is a shelf with many different suppliers, a section dedicated to each supplier.”

Case B – Participant 2: “The biggest challenge in this industry is to manage the unknown; which product and which size they might use next. Every patient’s anatomy is different and each will need a uniquely suitable product, so you need to have the whole range available on the shelf to operate. If you do not supply the whole range, it means you lose business and to forecast this is very difficult. You predict according to fast moving items, but besides that you still have to have the full range available. Thus, when doctors do agree to use your product, the full range will have to be available on the shelf. This is a live and forever evolving business. One week the doctor might be operating on 80 year old ladies where the vessel structures differ vastly compared with that of 40 year old men. So even for the doctor it is very difficult to predict. So in order to be player in that game, you have to have the full range available and always follow up to ensure the right stock is there.”

CASE C

Case C – Participant 1: “Doctors locally here in South Africa self-refer, which does not happen internationally as much. Because our doctors do everything, the patient gets booked today for a cath. So today he goes onto the table for his diagnostic and if he has a lesion, they carry on there and then and do the procedure. He does not come back a second time for somebody else to do the procedure and that is why we do not know what products will be used.”

Case C – Participant 2: “In the past, the hospitals used to buy their own stock. But companies destroyed that kind of philosophy through saying I will just put it on your shelf. That was obviously impressive for the hospitals and they completely changed over. Certain items available for every single operation will be bought; these might include guiding catheters and guide wires.”

Appendix 8: Additional comments – Research Question 2

Hospital Interviews

CASE E

Case E – Participant 1: “When a product is listed, pricing will be shared as well as how often the product will be used and what doctors are planning to use the product. This will determine if we would put it on stock or on consignment. For example, if it is an emergency product, which we will use once in three months, I will ask to have it as consignment. If it is a new technology and the doctor is so happy that he will use it in every case going forward, we might opt to put it on our own stock.”

Case E – Participant 1: “The consignment process is a long process so will rather keep it as our stockholding in the event of high volumes being used.”

Case E – Participant 1: “I feel that the ideal will be to eliminate consignment stock and have everything form part of our stock holding. Consignment stock will in all probability always be around.”

CASE F

Case F – Participant 3: “The hospital does not keep any stents or balloons on stock. We have tried one item in the past, but it then expired so no, stock is kept on consignment. Things that do move like guiding catheters and guide wires, they are kept in stock. Guide wires and guiding catheters are also lower in value, around R2000 a piece, but they are fast movers anyway. The consignment stock process takes us more time also so it is better to have those fast movers as stock.”

Case F – Participant 3: “We cannot move away from consignment stock because what else? We cannot buy the stock; it will result in major losses. In the state hospitals, they often buy the stents and sometimes they don't even pay the suppliers, for example 6 months down the line and still no payment. In terms of a future look, I cannot see us change to something else, the system we currently use works well.”

Case F – Participant 2: “I cannot see our hospital group moving away from consignment stock.”

CASE G

Case G – Participant 2: “Our own inventory in the hospital is currently on 24 days, more specifically 13 days in the cath lab. These are made up of fast moving items like drapes and guide wires. Slow moving items like balloon, catheters and stents are kept on consignment.”

Case G – Participant 2: “Reps try and convince us to keep fast moving stock items and move away from consignment. We cannot do this because budgets do not allow for that to happen. We cannot take the risk for write-offs due to expiries and where stock is not charged etc.”

Appendix 9: Additional comments – Research Question 3

Supply Company Interviews

CASE A

Case A – Participant 1: “Forecasting is a collaborative effort, usually between the product manager and the supply chain department. In terms of levels on consignment, hospitals do not dictate and we do not decide. We will sit down and discuss and obviously they have a lot of influence on it, but it will be an informed decision made by both parties. If you know the doctor is going to use it, then you are very happy to put stock in there and if you know the doctor is not going to use it, you are happy to take stock away as well. So it works both ways.”

Interview question: Does your company have an EDI link with the various cath labs?

Case A – Participant 2: “So, it is like an OrderWise type situation. We do not have an EDI link with our cath labs. We have it with certain pharmacies, but not with the cath labs. Life [hospital group] does not have OrderWise. Netcare and Mediclinic [hospital groups] do. And we use the OrderWise system, but we certainly do not have an EDI link with any cath lab, no. So, they use the OrderWise system to place their orders, but there is definitely no EDI links with any cath labs.”

Interview question: Have you found that government often does not get the signal to you on time so the rep has to visit the hospital?

Case A – Participant 2: “No, we have found that government never gets the signal to us on time. So with government, the time from usage to letting us know that it needs to be replenished, unless your rep is actually there, they can take two, three weeks because they do not bother with that at all. They leave it entirely up to the companies. And, even once they have used it, the administrative side of them generating that order can take forever. So government is a completely different kettle of fish.”

Case A – Participant 2: “There is very little you can do. I mean, obviously, one tries to build relationships with the people in the hospitals, but, you know, whatever we have tried in government, and I think most companies will say the same thing, it generally fails. This is because there is a massive turnover of people within the government

departments, they do not give a damn and the doctors have no control whatsoever over the order departments or even the stock controllers. So the bottom line is, if your rep did not go there once or twice a week, you would not get that information.”

Case A – Participant 2: “Government is not even worth talking about, to be honest. Really it is not. If you are not there yourself, it just does not happen. But in the private sector it works very well.”

Interview question: What about the private sector?

Case A – Participant 2: “In the private sector, those signals are done very, very speedily because once that patient is discharged, they have to charge them anyway so they need the invoice. So they generate it very quickly. So it is generally within 24 hours if not sooner in most cases.”

Case A – Participant 1: “From a private point of view, if there is a supplier delay in terms of the invoice to the hospital, the follow up to that is a phone call. They will say we need the final bill; we are waiting for the invoice. I got two this morning saying if I do not have it by 10 ‘o clock, it is free of charge. So they do follow up.”

CASE B

Case B – Participant 1: “Signals coming from private hospitals are quite quick. The public sector is extremely poor; it can even take up to a year. For me, the public sector is not worth it.”

Case B – Participant 1: “There are extreme delays, which occur primarily in the government sector. You will find that all our government customers have issues. It is a nightmare dealing with government. Private is generally good because they have a need to get that patient billed. In government it can take weeks or months for the signal to come in, so we often replace even before getting a signal from the hospital.”

CASE C

Case C – Participant 1: “Currently, we can already do same day deliveries and those are not classified as emergencies. It is about getting that daily delivery as a standard, if the customer uses it this morning it will be there this afternoon. The signal has to get to us sooner in order to make this happen.”

Case C – Participant 1: “Mediclinic and Netcare try to also monitor themselves and supplier performance on their side to ensure that an order gets put through to the supplier within a certain amount of time and then they measure the company based on how long it takes the company to get the product back to them. As soon as the hospital has placed that order in OrderWise, the clock starts. It measures the supplier’s response rate in terms of how quick we are to respond to acknowledge their order, to acknowledge we have stock available to ship for delivery the next day. The hospital therefore measures the supplier’s response time.”

Case C – Participant 1: “The reps also know which accounts are the bad ones. They know when the doctors had a big list and a lot of products were used and if they do not see it on their sales the next day they would go straight to that hospital stock controller and ask where are their orders. It is always the same hospitals where these issues come from generally. Even in private hospitals also. Reasons are that the person is just responsible for too many departments’ worth of inventory and that is why they are so far behind or they are lazy, but generally you know which ones it is. Public hospitals work completely differently and even within public, each hospital is on a whole different order system. One would think that from a government perspective all will be ordering from the same system, but each do their own thing and are completely different.”

Case C – Participant 1: “Reps go to the state hospitals nearly every day to check the books to see what has been used and physically driving the process, the public sector is very rep reliant.”

Case C – Participant 2: “We have encountered instances where at the hospital the stock controller has either been busy, off or lazy and we have only received the order with the usages two days after the operation took place. So in that case we will not know, so the replacement stock is only triggered on the usage requirement that is sent to us for invoicing. So it is only when we get the request to invoice that we will replace. The exception is when a rep knows that a whole bunch of extra cases are lined up and they might phone upfront and say: ‘listen, you might not have received the orders for

invoicing, but please send out the replacement stock in the meantime.’ – That happens very seldom. The trigger is the hospital sending us the order. The problem is that there is system as well as people delays and the trigger often gets to us late.”

Case C – Participant 2: “The public sector is only 10% of our revenue. In Gauteng, a lot of the public hospitals try to standardise their processes and try to walk through the same sort of steps as the private sector, but then amongst provinces they are quite different. So the usages are not always available and they actually rely on the rep to go back to the hospitals and to get the details and to walk it through the whole process of getting an order number. Albert Luthuli is a good example where the staff members are quite happy to send them the usages, but they don’t have the equipment. No fax, no e-mail, cannot scan, cannot send them the detail. So they ask the rep to come, get the request for purchase (RFP) form with the usages on them to walk through the department to get an order number. Our company is, however, now allowed to invoice on that RFP number so as long as the rep goes to collect it, we can invoice. We have now even gone as far as implementing copy machines in some of the cath labs as originals are not allowed to leave the hospital...now they can bring these back to the office so that they can actually invoice goods and have them replaced.”

Case C – Participant 2: “We have no real EDI link at the moment, OrderWise is not a complete link and is one-sided still. And EDI should help the signal to come through instantly and we will be able to get by with half the number of resources. There are already barcodes for the each patient. So all the hospital need to do is to scan the patient’s barcode, scan the product and there is your order - but it is just to build that interface.”

Case C – Participant 3: “If the hospital wants to order more than what our system tells us to keep, customer services will inform supply chain who will also review and will decide if the order should be released or rejected. If hospitals or reps want to keep more, they will need to provide reasons for the decision, for example a case coming next week.”

CASE D

Case D – Participant 1: “In terms of EDI, there is an interface called OrderWise where one of the hospital groups uses it for order processing and we process it into our ERP system. I would not say that they integrate it in terms of interaction between the two automatically; there’s still human interaction needed. Orders mostly come in

through customer service and their process to give you a holistic view is e-mails, phone calls or EDI from OrderWise.”

Case D – Participant 1: “Cross functional visibility is a big driver across the supply chain. Conversations are happening between the sales team and the ops team.”

Case D – Participant 1: “So we give the reps all the black and white motivation to actually have the conversation with the doctor, but I can see it not being that easy. Although it makes perfect sense for us as a supply chain, it is all about what you see on paper and the facts and it is easy to make a suggestion based on that. But when you take into consideration the actual circumstances that the sales force face in the field it is sometimes not that easy.”

Case D – Participant 1: “From a private hospital perspective, the signal comes in within a day. With that said, again, the interaction between our service team and the hospital in terms of consumption and ensuring that the signal is pushed across quickly and we can replace, for that to happen, both parties need to be on the ball. You will find that certain hospitals are particularly efficient and you will find other ones that are poor. And that is just the way that they manage their stock, unfortunately. In that case, the customer supervisor will have the conversations with them and be fairly honest and just explain to them that although it is not a case of ‘we are picking at what you are doing, but please understand the consequences of how you are managing your stock at the moment. If you want next-day delivery and if you want to run a lean stockroom of our products then we need the constant flow of information to ensure that we replace the next day and things run smoothly’. It’s not uncommon to find that hospital is asking for short-term stock because someone has not placed the order for the consignment replacement which is, again, we cannot really point fingers, but we understand why that is happening. It is poor consignment management from our point of view. In general, the signal is received within a day, so next-day deliveries are what we do.”

Case D – Participant 1: “In terms of government delays, I am not going to put a number to it, but delays are severe in most cases So, it’s becoming the norm to really understand the paper flow and the purchasing process at governments to push through and see how quickly you can get the stuff through and not to sit back and assume that it’s going to come and trust their system. Look, it varies from government to government, but in most cases the reps need to really chase it and they should because it is huge orders compared to private. It is really good sales coming your way

so it is unfortunately what you have to do as a rep. With government, it is a continuous process and cycle to ensure that you get the order numbers.”

Appendix 10: Additional comments – Research Question 3

Hospital Interviews

CASE E

Case E – Participant 1: “As the stock is used, it is the stock controller’s responsibility to fax or e-mail the order to the supplier’s representative. The sister will come to the store room and ask for a specific stent based on a certain procedure, or take the item and it is her responsibility to inform the stock controller that the item has been used.”

Case E – Participant 1: “Responsibility of stock lies half with me and half with the theatre. Our policy is that either all consignment stock is managed by the pharmacy and theatre or to have it fully managed by the theatre. The latter was the process when I got to the hospital, but the contracts were not managed at all, I then changed that. So myself and the theatre need a copy of the contract and both of us need to know what is going in or out of the unit. Unit manager will also sign and the final copy will be managed in a file in my office.”

CASE F

Case F – Participant 3: “Replacement of stock happens within a day or two. Stock controller will e-mail the representative or the supply company and the following day it will be replaced.”

Case F – Participant 2: “The supplier has two days after a patient has been discharged to invoice the hospital. Company’s turnaround time is generally within eight hours. The supply companies have dedicated people looking after certain hospitals and we e-mail them directly. Orthopaedic is different, the reps take the set back to the company, assess what has been used and then match with what the hospital said they have used. But in cath lab we work off a lot and reference number, as well as a doctor’s name and they are more than happy to bill us. A consumption signal in the form of an e-mail is sent to the supply companies within 24 hours after consumption. The cath lab’s operation is like a heartbeat, busy and then quiet. Like on Mondays, the list only starts at 12h00, only two cases are done and they finish at 14h00. Nursing will then sign off, which items have been used and will give the details through to the stock

controller and he e-mails it out on the same day. Some lists are bad and they book 10 – 15 patients a day, those signals are only sent the day after. All stents come with a sticker and nothing is written, we just stick them onto the order form, on the patient's charge sheet and that is the documentation, which is e-mailed to the suppliers. There are four to six stickers, the doctor also sticks one on his notes and takes it back to his rooms, one in the register and another on patient's charge sheet. All data is then sent off for archiving should a product be recalled for some reason."

Case F – Participant 2: "...some supply companies' couriers are here by 10h00 in the morning. There are stickers on the boxes stating cath lab or theatre. Delivery notes have referrals on them stating where it came from and where it needs to go to. The stock controller puts the items on the shelf in the cath lab and mark on his order book that he has received it. We rarely get the wrong stock delivered to us."

Case F – Participant 2: "The signal is sent to the suppliers within 24 hours after consumption has taken place. Our hospital is looking at a new technology where billing goes back to the nurses where, by the time the patient leaves the lab, the billing excluding consignment stock will be done immediately. The charge sheet will thus automatically go to the stock controller. That should shorten the time of signal to supplier as other products would have been taken care of and the stock controller will only quickly do the consignment items. Now they are capturing the charge sheet itself, finish the charge sheets and then only start with what was used on consignment."

Case F – Participant 2: "There is no EDI interface between the hospital and the supplier for consignment stock, only for normal stock on certain items."

Case F – Participant 2: "The floor nurse will then handle the stickers and the charge sheet. And the stock controller will do the billing and e-mail a specific person at the supplier. Some are phoned through, but most are e-mailed so that we have a record of it. In the cath lab, the stock controller is also the billing clerk."

CASE G

Case G – Participant 1: "After a consignment item has been used in the cath lab, the cath lab has a triplicate book. The patient's sticker goes onto the first page and the file goes to our consignment coordinator, she only handles consignment and do follow ups on invoices with the suppliers. She then phones the supplier or sends them an e-mail

with a copy of the patient's details. The supplier will then invoice the hospital and the device will be replaced. After receipt of the invoice, the hospital can bill the patient."

Case G – Participant 2: "Suppliers have 24 – 48 hours turnaround time to invoice the hospital; the hospital therefore tries to get the consumption signal to the hospital as quickly as possible. Some suppliers are quick and others not that quick. There are dedicated people working at the suppliers handling orders, this makes it easier for the hospital to follow up on queries and track outstanding invoices."

Case G – Participant 2: "The consumption signal starts with the theatre nurse. If the case took place in the morning, the requisitions will go to the consignment coordinator that same afternoon where the necessary will be sent to the supplier that same day. An afternoon case will only be sent to the consignment coordinator the next morning. The hospital's aim is to close patient files as quickly as possible."

Case G – Participant 2: "The hospital is looking at a system where an e-mail is sent directly to the supplier upon consumption and to do away with the manual process of sending an e-mail. Inventory stickers will still be peeled off and stuck on the patient file should they need to trace a product if something goes wrong and products need to be recalled."

Case G – Participant 1: "Doctors often know in advance what sizes will be used in a specific procedure. These signals are not communicated to the suppliers in most instances due to the fact that stock is already on the shelf on consignment"

Case G – Participant 1: "Competition in this industry has become very fierce compared to a few years ago. Lead times to the cath labs are generally good as supply companies try to build relationships and protect their market share. Doctors are not happy when items run out of stock and they do not have to look very far for replacement products from competitors. There are many generic and more cost effective products on the market, service in this industry is therefore of utmost importance."

Case G – Participant 1: "Representatives as well as the pharmacy staff members will see when product is not moving. A joint decision will be made whether to reduce or remove those slow/non-moving stock items. Inventory cannot just lie on the shelf without moving. One can easily see whether a doctor likes a product or not, if there is an argument between the doctor and the supply company, the doctor will outright stop using that supplier's products. This industry is very doctor specific."

CASE H

Case H – Participant 2: “Reps are often present in the cath lab. What they sometimes do is they contact their head office and ask to replace a specific item even before the hospital has processed the order. This ensures quick replenishment and product availability.”

Appendix 11: Additional comments – Research Question 4

Supply Company Interviews

CASE A

Case A – Participant 2: “Multiple signatures safeguard us to make sure we do not overstock. It is that simple because one of the biggest problems that we have had that we eluded to in the beginning is expiries. You don’t want to be sitting with that.”

Case A – Participant 2: “We monitor and rotate our soon-to-expiries. Probably more so at the moment than what we have ever done in the past. We are moving into an area now where supply chain has been given a mandate where anything that has not moved in a hospital within a certain period of time, will not be replaced. It makes sense, but whether the hospitals are going to accept it is a different ball game. And we have started moving in that degree as well. So, now we are saying, if it has been there for a period of time, let’s say in excess of six months to a year, and it was never been used, then it is unlikely that it is going to be used and we are not going to replenish it. It is going to cause trouble. We understand that, but we want to see at what point it causes trouble and at what point people are going to realise that it is actually happening. Funnily enough, the biggest stumbling block to this is the sales and marketing team to get their buy-in. And I am saying, well, if he has not used the product for a year and he does not know it is not there, unless you tell him...”

Case A – Participant 2: “So perhaps now is a good time to talk about the returns policy. So, on the cardiology products we have an agreement with our international supplier. Depending on the condition of the box and everything, if we send it prior to seven months to expiry, they will replace it for us. There is obviously a cost involved in returning it and a cost in getting it back. So when we talk rotations, those are only the ones that are under six months that we could not send back because the box was too damaged or whatever the case may be. We need to work a lot smarter on that particular returns policy, but we have that from our supplier.”

Case A – Participant 1: “Yes, so what they do is they give you a credit for whatever you have returned and you need to order to the same value.”

CASE B

Case B – Participant 1: “...if sales are poor, you will see an increase in your write-offs. They are directly proportionate.”

Case B – Participant 1: “...it is counterproductive to outsource the monthly counts at hospitals to companies other than the supplier reps, it takes away the face time and by outsourcing the counts you are spoiling the reps. Having the reps at the hospitals also assists in stock rotation as these outsourced companies are not allowed to do so. Rotations are done in an attempt to reduce write-offs.”

Case B – Participant 2: “Stock rotations have not been properly performed in the past, but it will be done now, it is part of the reps’ key points to actively do rotations and to have a plan in place. Hopefully, less stock will be written off.”

Case B – Participant 2: “International suppliers sometimes send short-dated stock, which is then rejected and returned to them.”

Case B – Participant 2: “We will put stickers on our close to expired stock items stating ‘use me first’. All the other companies are doing the same so it is very difficult to measure.”

Case B – Participant 2: “Reps have to do the stock counts. Every time they are in the hospital, it is not that they sell, but they are collecting information. If you do your stock counts, you compare your stock with your neighbour’s stock levels and realise when stock is not moving but the others’ are. Or your stock has been moved where no one will look for your stock. So the minute you neglect this and feel too casual about your consignment stock counts, you are out. It is an easy way to sell, you must just maintain good service. Do this because you are already half way in. Product is on the shelf, now service it properly. You now know what is happening in theatre, you speak with the nurse, etc., by talking to them you collect information and that is what I am telling everyone – You are not selling, 80% of the time you are collecting information.”

Case B – Participant 2: “Consignment agreements are more for private hospitals, but also for government hospitals depending if they are well organised and structured. You cannot just walk in and put stock on the shelf. You also need to know what stock should be there, so next time a device is missing you can say to the sister, ‘here is my stock list, which we have signed and now my stock is gone, what happened?’ So you have to prove that something was in place. To make the collaboration more efficient,

the count sheet is updated as an addendum. The sister also has to sign to help management to see that the stock take was in fact done.”

Case B – Participant 2: “If you are out of stock, you lose credibility and trust with the client, which has a significant impact on sales. Stock outs damage relationships. It is therefore crucial to get the product mix right. The correct level of stock has to be worked out hand in hand between supply chain and sales. Supply chain might want to reduce stock and sales overstock it, so there is potential damage on the customer side and damage on cash flow.”

CASE C

Case C – Participant 1: “According to our own internal agreement, we are supposed to count consignment stock once every month and some of the bigger volume hospitals have a rule that the reps need to count there twice a month. If they do that and stock goes missing they are covered. Stock is very carefully managed.”

Case C – Participant 2: “...the whole idea behind par levels is to ensure products are turning and to not overstock those consignment accounts. Par levels are set up by product by customer, if a request comes in which is greater than the par level, the order will get blocked until further analysis has been done. We need to make sure that our products turn, if not there will be write-offs.”

Case C – Participant 3: “We publish weekly consignment reports with stock details and expiry date. The reps have access to these reports and manage the process accordingly.”

CASE D

Case D – Participant 1: “...when it comes to the forecasting of devices, it is critical not to get anything you did not ask for because at the end of the day, you will not be able to sell it, number one, you will take the scrap cost and because these items have such a high standard cost it really hits you hard compared to other divisions.”

Case D – Participant 1: “Non-moving stock can be returned to our Tier1 DC [international]. There are, however, various hoops you need to jump through to get regional approval like shelf life, value and global demand for that product.”

Case D – Participant 1: “A few damages might come through where hospitals do not make sure returned stock is properly protected. I suppose that would happen anywhere, so it is not specific to the courier that you are using, it is more about educating the customer.”

Case D – Participant 1: “Twice a year, we go through a process called a slow-turns exercise. The slow-turns is a country-wide exercise where we look at what we have, what sells, the penetration rate and all of that, specific hospitals by division, etc. And then we pull stock back and then based on normal usage it then get pushed into hospitals that are faster moving from a consumption perspective.”

Case D – Participant 1: “...in terms of days inventory on hand, we are hovering on around 135 days but the plan is to get down to 100 days.”

Appendix 12: Additional comments – Research Question 4

Hospital Interviews

CASE E

Case E – Participant 1: “Company representatives will put short-dated stickers onto the products nearing expiry, which is usually six months shelf life to go.”

Case E – Participant 1: “Ideal is that when a patient walks out of the hospital, they should have their bill with them, this does not always happen though. Stock controllers need to be skilled and need to prioritise small cases first because those patients will be discharged first. Skills and inexperienced staff are a big problem we currently sit with. Staff members need to be trained and retrained, they need to understand that they form part of a chain and everyone needs to adhere to their targets. To find skilled stock controllers is hard, they play a vital role in this chain.”

Case E – Participant 1: “...if reps monitor their expiry dates closely it should not be a problem. There are no major issues which I am aware of. If it was our own stock, monitoring of expiry dates would have been the theatre stock controller’s responsibility.”

CASE F

Case F – Participant 1: “...reps have a list of products on their iPads and when they do their stock checks every two weeks, they know exactly what is missing. Some supplier reps have bar code scanners. Stents generally do not go missing, sometimes the stent is in transit and appears to be missing, but there are already an order number, which has been done by the stock controller.”

Case F – Participant 2: “...reps come in twice a month to do their counts and to check if items are not missing and the list will be signed off. If they add products it will be added as an annexure to the contract, the supplier will generate a new list and send it to us. We send consignment values to head office for insurance purposes should the hospital for example burn down. If something goes missing, reps will need an order number for the missing stock items. Each stent is connected to a patient and records

are strictly kept. So if a stent goes missing we can investigate why it was not billed, do the necessary and see if we can get it claimed from the medical aid.”

Case F – Participant 2: “...reps are responsible for stock in the cath lab and expiry dates of those products. They have a list. Often they will arrive with ten stents and also take the uncommon or close to expiry date stents out and rotate to hospitals where they will be used. Some other hospitals have two labs and short-dated stock will most probably move quicker there. Expiries do, however, happen, some items only really move once a year.”

Case F – Participant 2: “... we run a daily report called the final billed list. If days from discharge are three or more and still open, I will query it with the stock controllers. They might have the invoice, but product code has not yet been loaded on our system. Head office does not go and load all product codes of all stents, the hospital requests them when they are used and it will go onto a price file. This process takes around 12 hours. We are not allowed to have a billing open for more than three working days.”

Case F – Participant 2: “A challenge we have is when technology is offline, but then we phone things through. It happens very rarely though.”

Case F – Participant 3: “Stents are collected for rotation when expiry dates are reached or when other hospitals had big cases and have run out of stock. The other hospital will phone and ask if they can borrow a certain size stent and they will then replace them. The supplier has a goods removal book, which the hospital needs to sign. They cannot just pop in and take what they want.”

Case F – Participant 3: “The Stock controller cannot authorise a removal. The stock controller will liaise with the theatre nurse because she will know what scheduled procedures are coming up, which will use the commonly used stock items. Theatre nurses know the doctors well and have worked with them for long.”

Case F – Participant 3: “Reps have to try and count their stock at least twice a month due to the high value of these devices, so if there is a problem they can sort it out as soon as possible. It takes the reps only around 15 minutes as they mostly have scanners. If there is a query the rep and the hospital sign it off.”

Case F – Participant 3: “...the stock level in the cath lab is just right. If stock does not move for six months I will ask the supplier to uplift his stock. New and new technology products will, however, sit for longer.”

Case F – Participant 3: “I do not experience expired stock to be too much of a problem, it is quite closely managed. Reps will mark short dated stock with stickers or talk to me or the other sisters and ask us to please use certain ones first. Sisters do not check expiry dates, which is the rep’s responsibility. For our own stock, we make financial provisions for write offs. Dead stock are often marked as dead stock or emergency because we cannot run the business without them, but we do budget for them to be written off, but hope for it to be used. We also do inter-hospital transfers within the group.”

CASE G

Case G – Participant 1: “The consignment coordinator cannot send the file to case management for billing before all the documentation has not been received. Pharmacy manager run a discharge report twice daily and can clearly see what is outstanding. This serves as a safety net.”

Case G – Participant 2: “The hospital can bill the patient without an invoice from the supplier, however, suppliers often give discounts on items used, which will lead to price discrepancies and extra work. We therefore try and wait for invoices from suppliers first. There can be up to seven or more suppliers on one patient’s file, so the patient billing is a complicated process...the hospital’s aim is to have a patient’s file closed within two days of being discharged”

Case G – Participant 2: “...if there is too much stock on consignment, inventory might go missing and then the hospital is liable. It seldom happens. It might happen that inventory is used and the nurse has not billed the supplier. Thus, the less inventory we keep, the better.”

Case G – Participant 2: “Reps have to come and check their own expiry dates, we at the hospital do not take responsibility for expired stock or counting their stock. Expired stock needs to be collected by the reps. Some companies have scanners which simplify stock counts.”

Case G – Participant 2: “...usage in the cath lab is generally stable and predictable, but when a doctor goes on leave the cath lab is overstocked. Sometimes stock is urgently needed and reps generally are quick to respond in an attempt to keep doctors happy.”

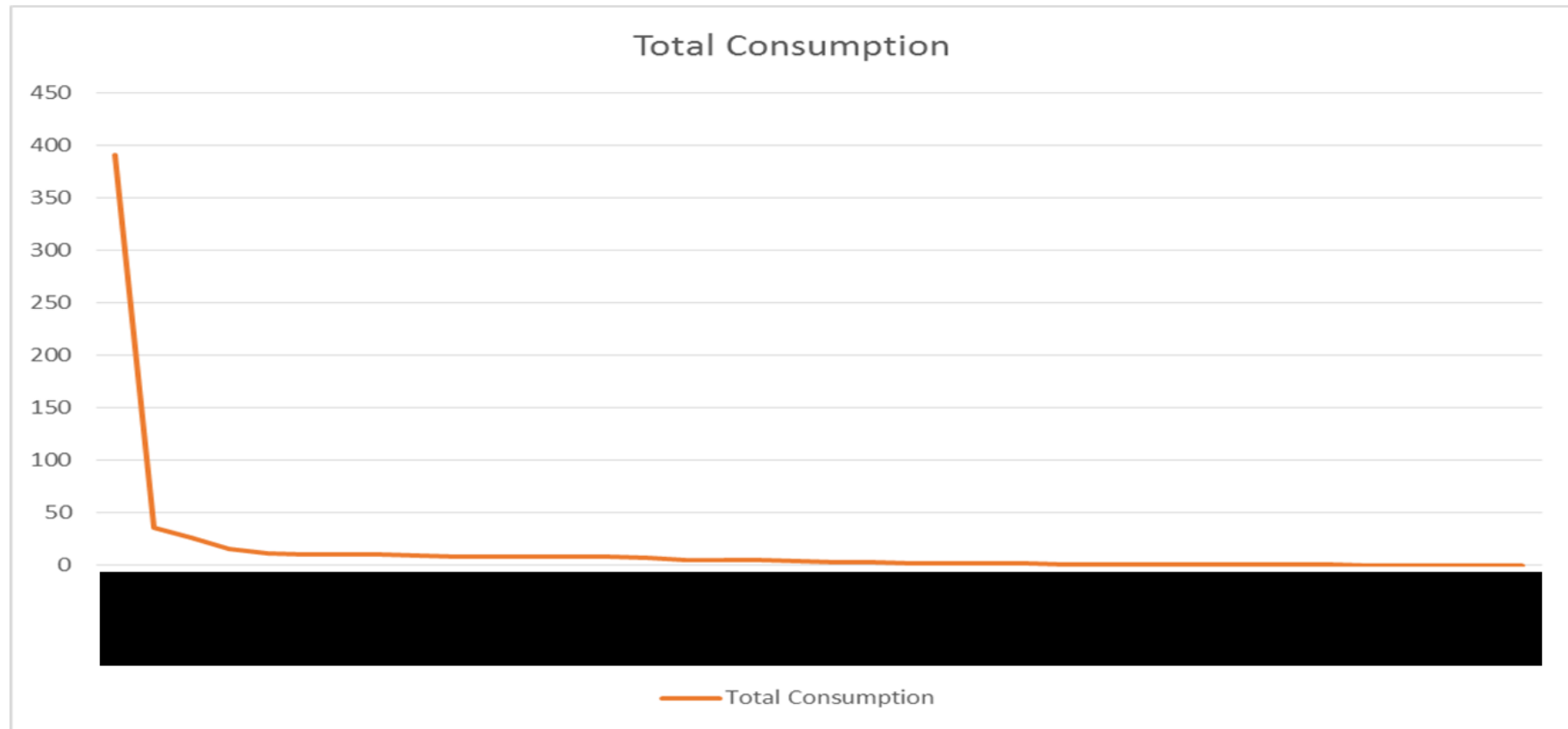
Case G – Participant 2: “Supply companies attempt to rotate dead stock, but all parties do not always play along.”

Case G – Participant 2: “I cannot say that the cath lab is over- or under stocked, it goes through phases. I have not, however, heard doctors complaining due to items being out of stock. I suppose the cath lab is slightly overstocked seeing that all sizes need to be on hand at all times.”

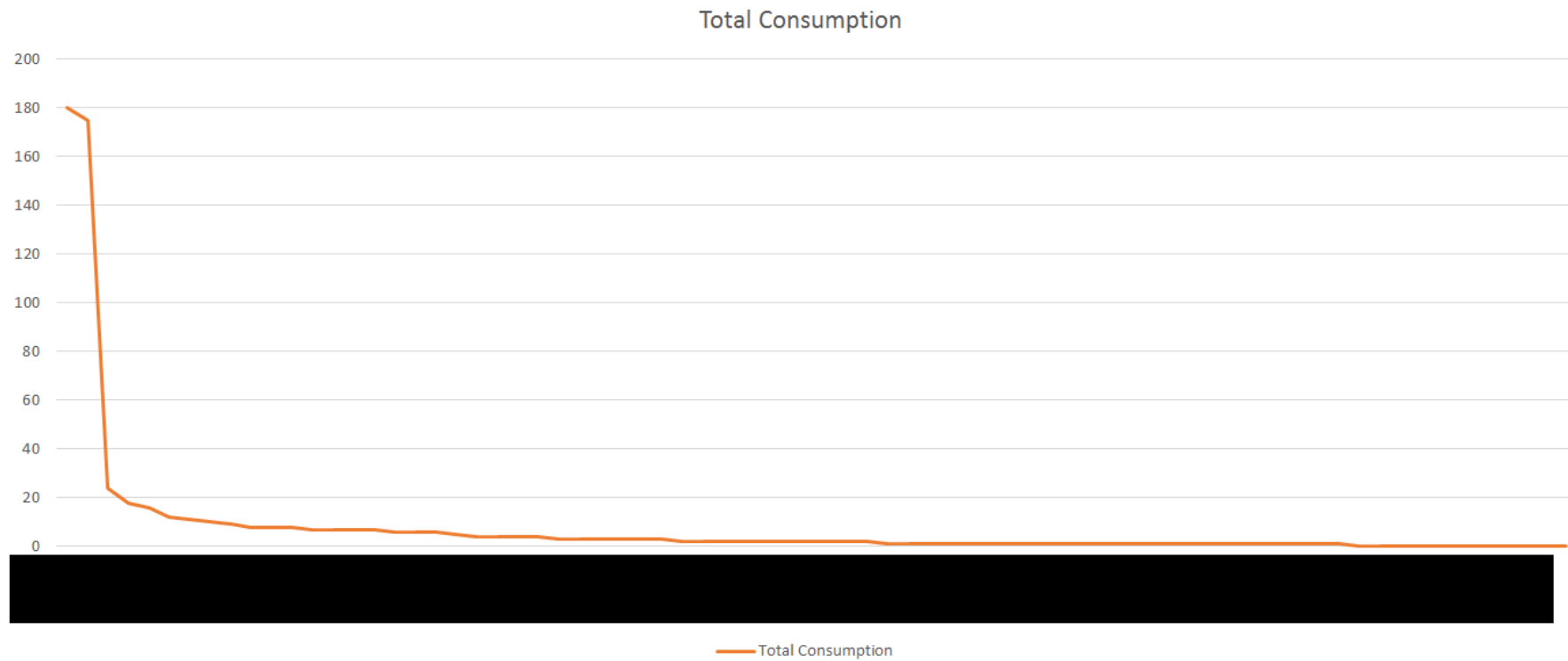
Case G – Participant 2: “Reps do try to rotate stock. They use a transfer document which the cath lab staff also signs when stock is removed.”

Case G – Participant 2: “Our own stock holding is made up of fast moving stock items but consignment stock items are mostly slow movers”

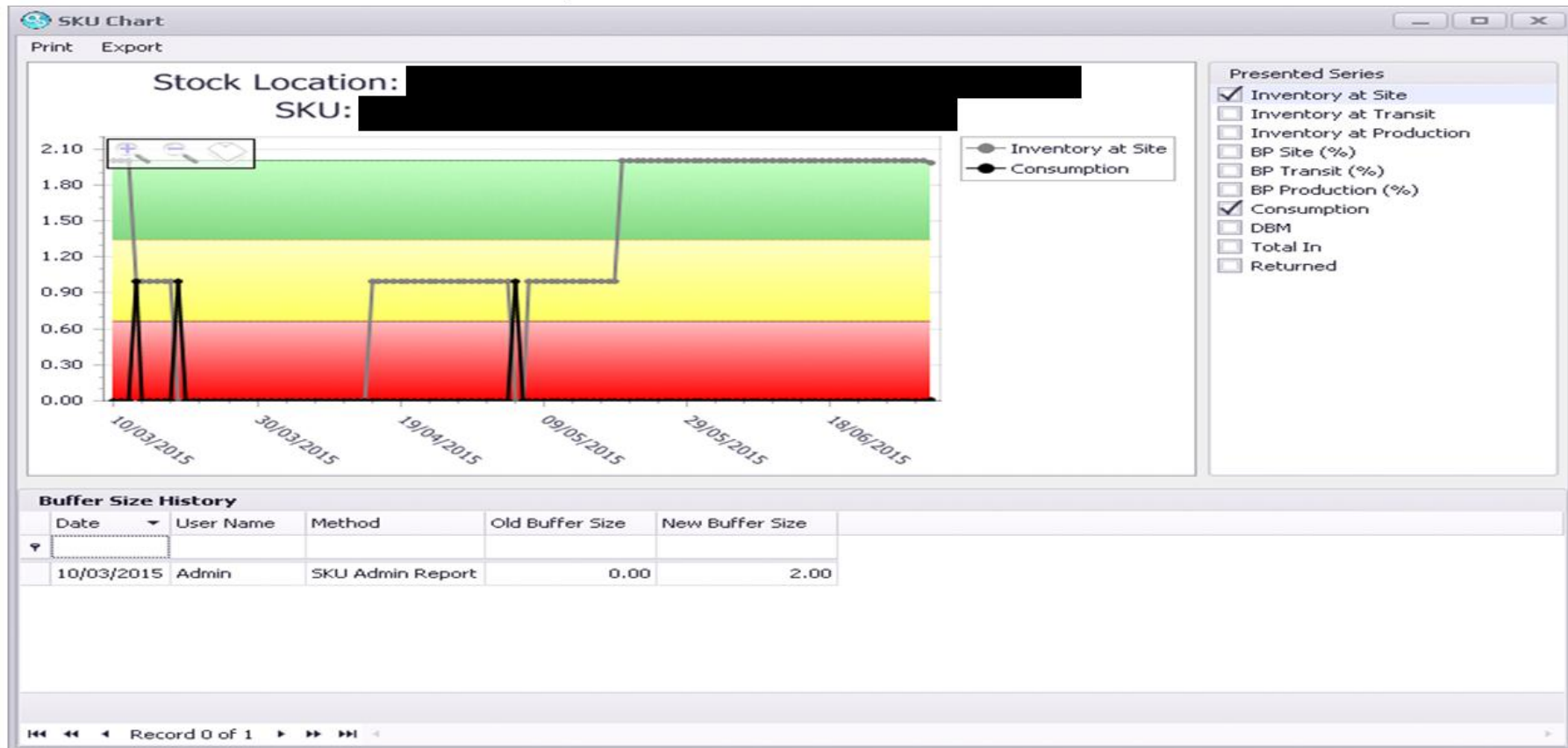
Appendix 13: Sales versus Stock location Chart



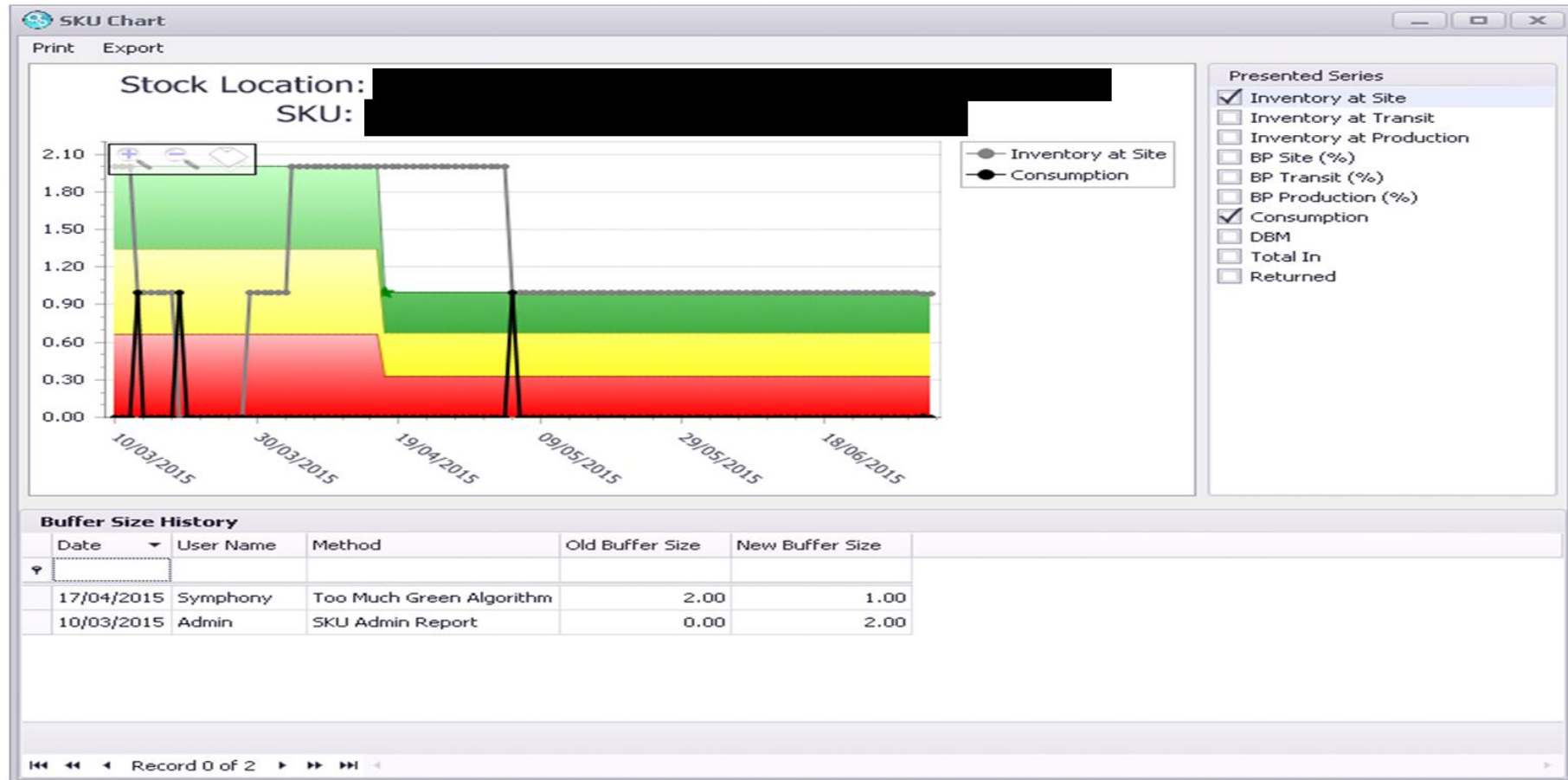
Appendix 14: Sales versus SKU Chart



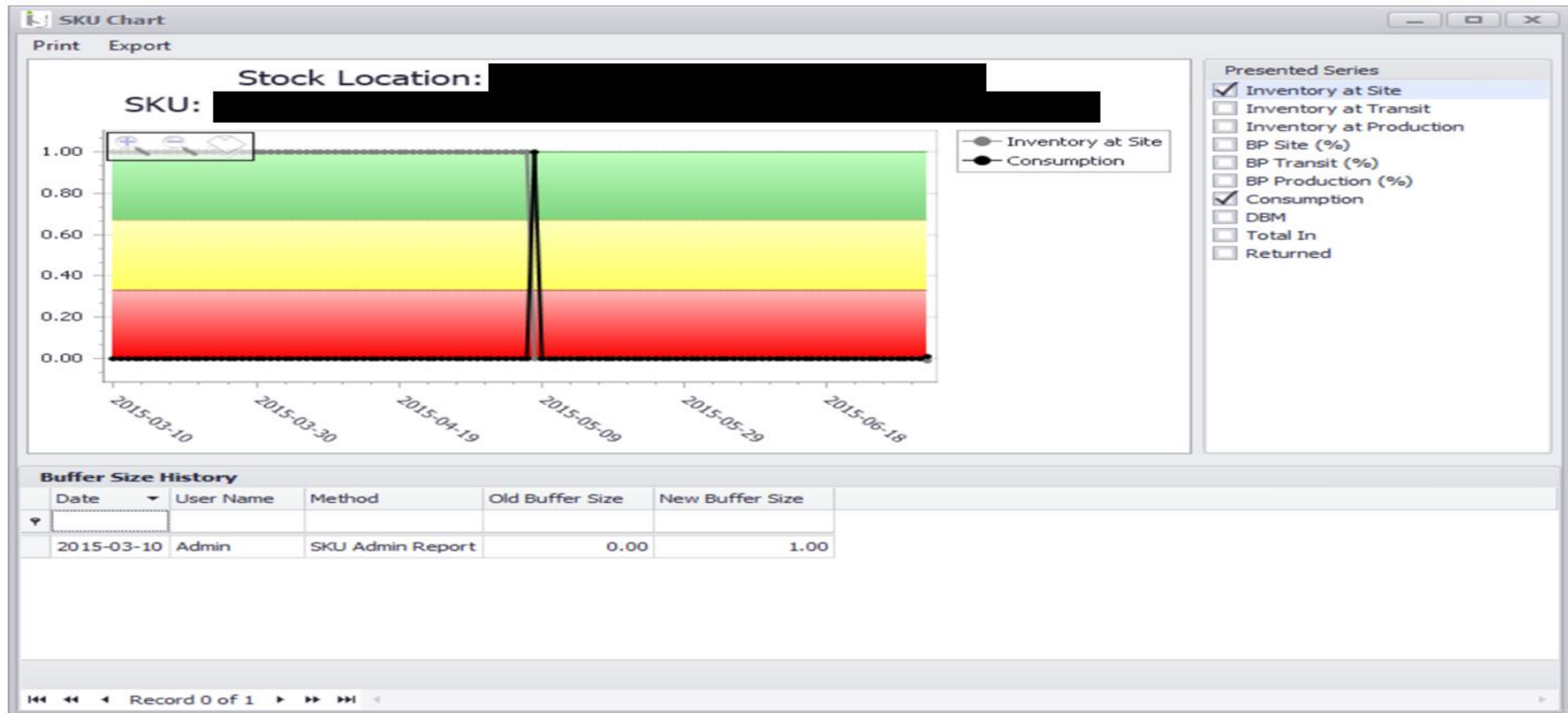
Appendix 15: Simulation SKU Chart – Current State



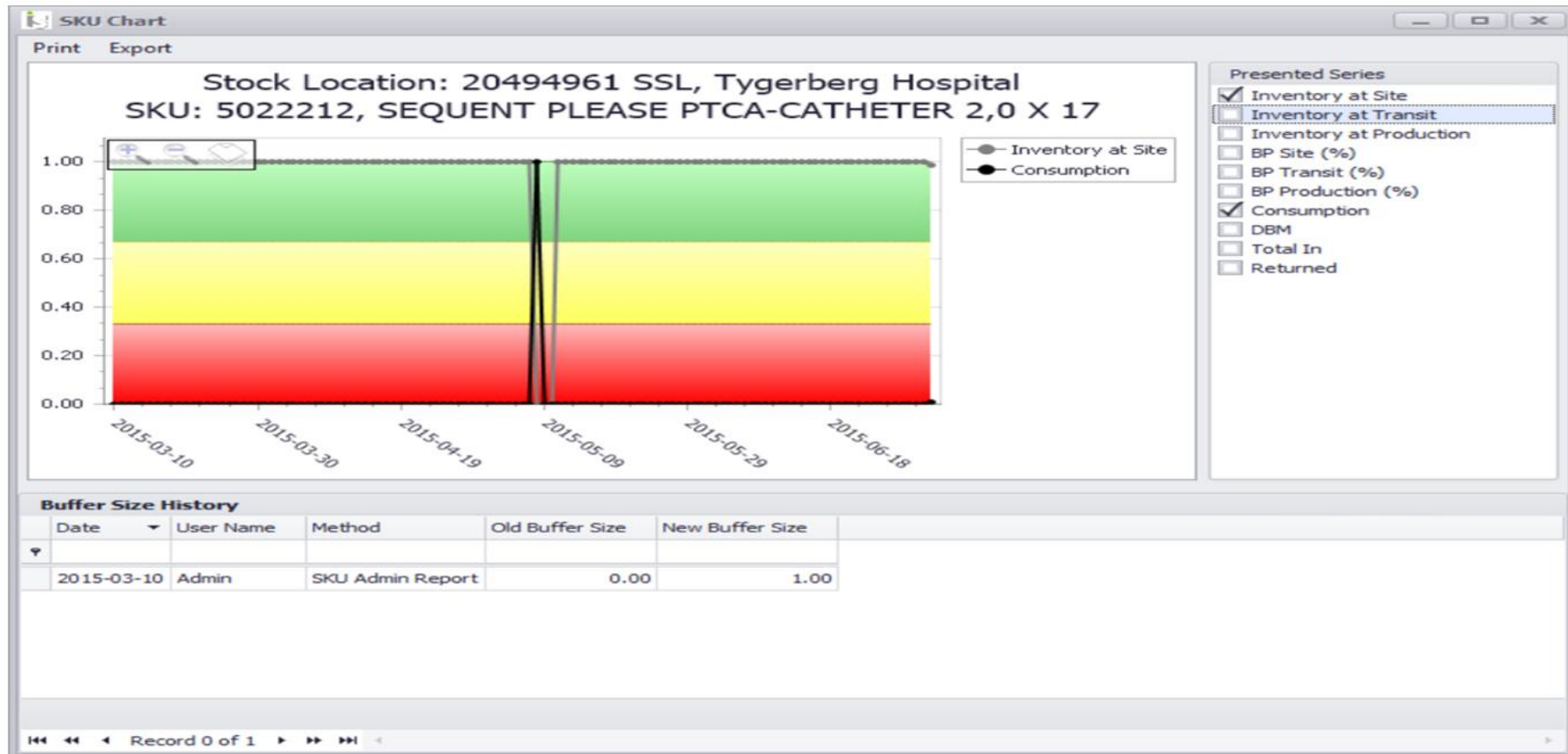
Appendix 16: Simulation SKU Chart – Simulated State



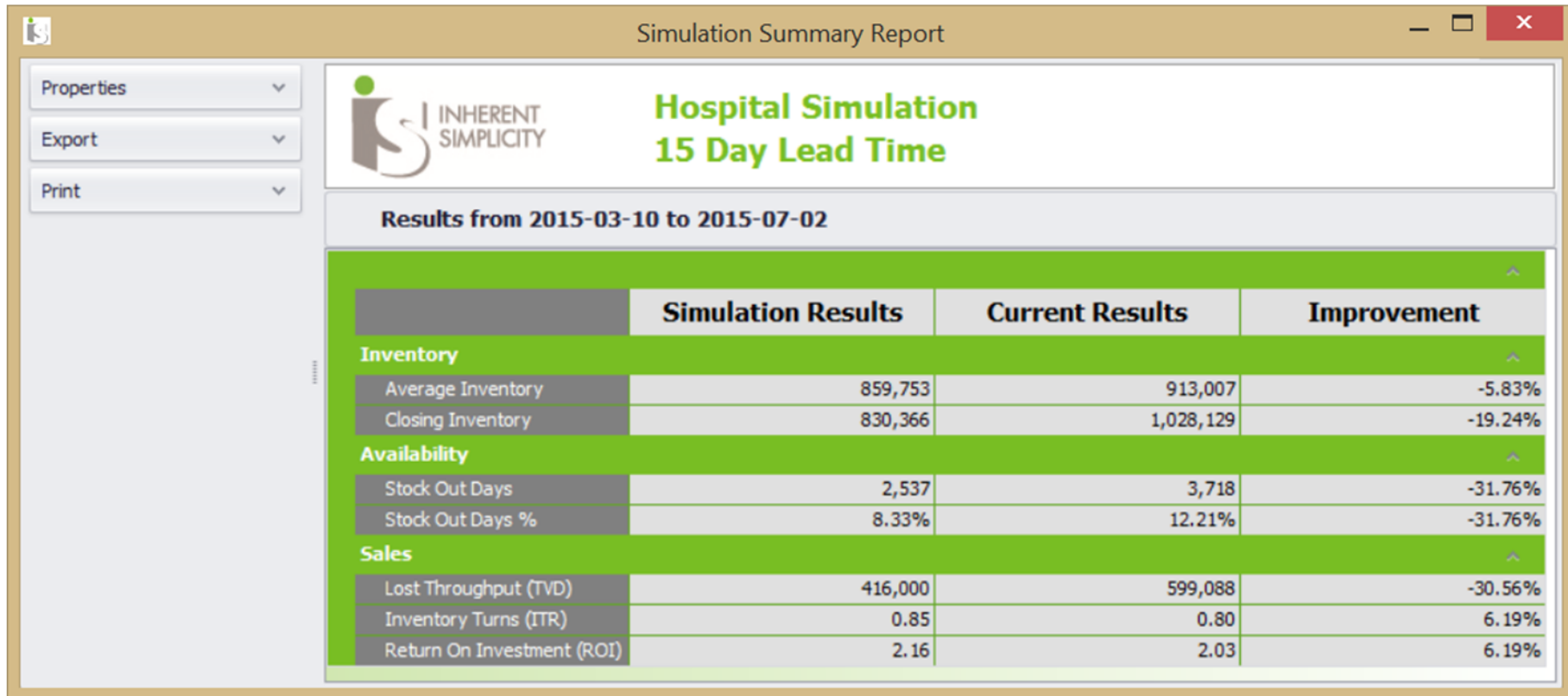
Appendix 17: Simulation SKU Chart – Current State



Appendix 18: Simulation SKU Chart – Simulated State



Appendix 19: Simulation summary report – 15 day lead time



Appendix 20: Simulation summary report – 2 day lead time

Properties

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INHERENT
SIMPLICITY

Hospital Simulation

2 Day Lead Time

Results from 2015-03-10 to 2015-07-02

	Simulation Results	Current Results	Improvement
Inventory			
Average Inventory	894,900	913,007	-1.98%
Closing Inventory	838,469	1,028,129	-18.45%
Availability			
Stock Out Days	556	3,718	-85.05%
Stock Out Days %	1.83%	12.21%	-85.05%
Sales			
Lost Throughput (TVD)	37,406	599,088	-93.76%
Inventory Turns (ITR)	0.81	0.80	2.02%
Return On Investment (ROI)	2.07	2.03	2.02%