A Conceptual Demand Driven Healthcare Supply Chain Management Maturity Model for the Public Healthcare Supply Chain in South Africa

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ABSTRACT

In both developed and developing nations, the healthcare industry is one of the most important segments. Therefore effective and efficient healthcare supply networks are prerequisites for supporting healthcare systems in search for meeting the needs of especially the poor and economically marginalized. However recognising that challenges such as unexpected surges and drops in demand can cause devastating effects on the ability of a healthcare supply chain to provide the right products and services to the right customer at the right time, this paper proposes Demand Driven Supply Chain Management (DDSCM) as an approach. This concept evolved from the SCM concept but is much broader than SCM. Among the multiple benefits that the DDSCM concept has to offer, one of the most relevant to healthcare supply chains is the ability to significantly reduce and lessen the impacts of stock outs. Multiple benefits of the DDSCM concept have been identified, but many operations managers around the world still consider this concept as a "Holy Grail." The purpose of this paper is to explore the enabling factors of DDSCM approach and propose a conceptual DDSCM maturity model for the public healthcare supply chain in South Africa.

Keywords*-demand driven supply chain management, maturity model*

I. INTRODUCTION *AND PROBLEM STATEMENT*

In South Africa, the gross domestic product expenditure (GDP) on healthcare is 8.5%, but the country still has poor healthcare outcomes in comparison to other middle income countries with lower levels of healthcare expenditure.(National Department of Health South Africa, 2010). With 25% - 30% (Mustaffa and Potter, 2009) of healthcare costs emanating from the supply chain, and 80% of the SA population that is dependent on public

healthcare (Foreword *et al.*, 1995), this highlights significant potential for more effective management and improved access.

It is also postulated that the public healthcare supply chain in South Africa is still in its infancy and is mistakenly conceptualized as procurement and contracts management (Berger *et al.*, 2010). This reflects a lack of understanding of the supply chain concept and this has led to many areas of the health care supply chain to go unexplored leading to poor healthcare outcomes (Kwon, Kim and Martin, 2016) and high expenditure.

Health care supply chain management involves the management, planning and control of four flows; medical products, information, finance and services from suppliers to patients. The concept further includes the coordination of supply chain partners (Ridwan and Norzamani, 2014). However, recognising that challenges such as unexpected spikes and drops in demand can cause devastating effects on the ability of a healthcare supply chain to provide the right products and services to the right customer at the right time, this paper proposes DDSCM as an approach. This concept evolved from the SCM concept but is much broader than SCM (Vaidyanathan and Howell, 2007). Among the multiple benefits that the DDSCM concept has to offer, one of the most relevant to healthcare supply chains is the ability to significantly reduce and lessen the impacts of stock outs. Multiple benefits of the DDSCM concept have been identified, but many operations managers around the world still to date consider this concept as a "Holy Grail." (Budd, Knizek and Tevelson, 2012).

Importantly the purpose of a healthcare supply chain is to serve the patient (Ridwan and Norzamani, 2014) and this requires the healthcare supply chain to be designed in such a way that the patient is the starting point of the supply chain and then moving backwards to the supplier. Therefore this study aims to:

a) *Explore the concept of DDSCM*
b) *Determine the enabling factors of DDSCM*
c) *Compare current supply chain related maturity models*
d) *Propose a conceptual DDSCM maturity model for the public healthcare sector*

The paper is thus organized as follows; Section II outlines the healthcare supply chain landscape, Section III unpacks the DDSCM concept, Section IV explores the supply chain maturity models. Section V will then outline the study methodology for the development of the DDSCM maturity model, Section VI Presents the conceptual DDSCM maturity model for public healthcare supply chain. Lastly Section VII presents the conclusion and future recommendations.

II. HEALTHCARE SUPPLY CHAIN

The healthcare supply chain consist of three principal actors; producers, providers and purchasers (Burns and DeGraaff, 2002).The producers are the pharmaceutical companies, medical device manufacturers and surgical

instruments manufactures while the providers are the hospitals, clinics, physicians and pharmacists. The purchasers include group purchasing organizations, pharmaceutical wholesalers and distributors. The healthcare supply chain also extends to include payers such as patients, government and medical scheme companies and medicines regulatory bodies (Burns and DeGraaff, 2002). The healthcare supply chain structure is shown in Figure 2.

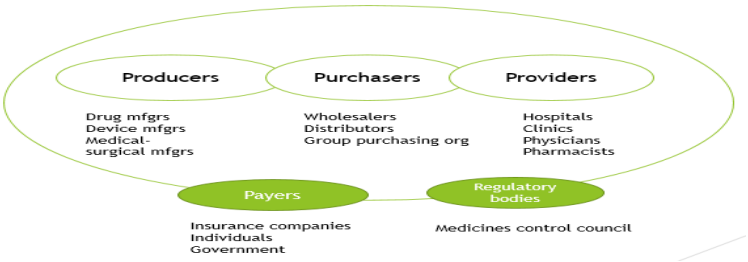

Figure 1: Healthcare Supply Chain (Burns *et al.*, 2001)

The public healthcare supply chain in South Africa uses tendering as a procurement system. The successful outcomes of the public tendering process are contracts offered to manufacturers and producers of either medical drugs or medical devices. The medical control council regulates all medicines in terms of medical drugs registrations and safety. Manufacturers distribute the medical drugs from their warehouses to regional warehouses in each province. From there the Department of Health (DoH) makes use of their own transportation systems or third party logistics to deliver the medications to all healthcare facilities around the country.

South African healthcare supply chain processes include demand planning, supply planning and distribution planning, inventory management, procurement and contracts management. Demand planning process involves the integration of statistical forecasting techniques, experience and judgement of planners to construct a demand plan. This demand plan takes into consideration the consumption patterns of health facilities, epidemiology and historical campaigns. This is all performed under the consideration of constraints such as budget, available supply and product changes (Ed Llewellyn, 2016). The demand plan is an input to supply planning. Supply planning involves the process of coordinating inventory and orders to optimize the delivery of health products to fulfill the demand plan. The outputs of supply planning are purchase orders and replenishment orders. Supply planning takes into consideration lead-time, stock at hand, safety stock, minimum order quantity and delivery channel costs (Ed Llewellyn, 2016).

Distribution planning is a process of scheduling shipment of healthcare products between warehouses and health facilities in response to a supply plan. It takes into consideration the constraints of storage space and vehicle capacity so as to optimize distribution activities (Ed Llewellyn, 2016). Inventory management encompasses the activities related to the management and control of inventory (Garcia, 2008) of healthcare products while procurement and contracts management includes actions related to procuring goods and services to meet

planned and actual demand (Stewart, 1997). This dimension is also viewed as supplier relationship management (Lambert and Cooper, 2000).

III. DEMAND DRIVEN SUPPLY CHAIN MANAGEMENT

A. Overview of the DDSCM concept

A demand driven supply chain (DDSC) consist of coordinated technologies and processes that collect, analyze and share real time demand and inventory information across all supply chain partners (Budd, Knizek and Tevelson, 2012). It is suggested that the combination of both demand and supply concepts give rise to a DDSC which is fundamentally a pull system (Mendes, Leal and Thome, 2016).

The development of the DDSC can be traced back to the evolution of the Toyota Kanban system (Hopp and Spearman, 2004) which emphasized a pull production system. In manufacturing context, a production pull system involves the amount of work in progress being explicitly limited as opposed to a push production system which does not limit the amount of work in progress. Pull systems can be classified as strategic where customers dictate the pace of production or tactical where the amount of work in progress is explicitly limited by demand (Hopp and Spearman, 2004). The push production system came into play due to the dawn of computer applications in manufacturing. Computer applications paved the wave of materials requirement planning (MRP), manufacturing resources planning (MRP II) and enterprise resource planning (ERP) (Hopp and Spearman, 2004). All these initiatives are push production systems. The push and pull systems are likened to make-to-stock and make-to-order respectively (Hull, 2005).

Studies in demand chain management (DCM) also unpacked the concept of DDSC. The DCM concept puts emphasis on practices that seek to manage and coordinate the demand chain, beginning with the customer then moving backwards to raw material suppliers (Selen and Soliman, 2002). Canever et al. (Canever, Trijp and Beers, 2008) view DCM as a concept that evolved from SCM but is much broader than SCM (Canever, Trijp and Beers, 2008). Many DCM studies made a strong emphasis on customer demand orientation as the core focus of DCM (Heikkila, 2002; Markham T. Frohlich and Westbrook, 2002; Juttner, Christopher and Baker, 2007; Canever, Trijp and Beers, 2008; Bonomi and Antone, 2014; Mendes, Leal and Thome, 2016) while others highlighted activities such as the integration and alignment of demand and supply processes (Markham T Frohlich and Westbrook, 2002; Juttner, Christopher and Baker, 2007).

In contrary to the concept of DCM, De Treville et al. (De Treville, Shapiro and Hameri, 2004) conceptualized the concept as only a change of SCM nomenclature and suggested that this change of nomenclature will cause confusion. However, they further acknowledge the co-existence of a demand chain and a supply chain. The only

difference is on the focus of each chain. Demand chains focus on market mediation and supply chains focus on efficient physical supply (De Treville, Shapiro and Hameri, 2004).

B. ***Enabling Factors for DDSCM***

The enablers of demand driven supply chain management include;

1) Customer Orientation

The customer is the starting point of the DDSC (Selen and Soliman, 2002). Therefore the first step is to understand the actual customer demand and translating that demand into strategies and plans. The strategies include customer segmentation (Heikkila, 2002). Customer orientation also captures the construct of accessibility of demand and inventory information when and where it is needed (Canever, Trijp and Beers, 2008) for planning and decision making purposes.

2) Product Classification

Products can be categorized as either innovative products or functional products. Functional products have a predictable demand while innovative products have an uncertain demand (Fisher, 1997)**.** Pure demand-pull systems are applicable for products with unpredictable demand and are costly. A hybrid push – pull system is suitable for products with high demand unpredictability but for which economies of scales in production and distribution are vital. (Mendes, Leal and Thome, 2016).

3) Information Communication Technologies (ICTs)

ICTs enable the capturing, analysis and distribution of seamless, real time demand and inventory information (Agrawal, 2012a). A fast data-exchange platform can facilitate the exchange of data in real-time among partners and is the key to implementation of DDSCM (Budd, Knizek and Tevelson, 2012). It also facilitates supply chain visibility, information integration, transparency and this enhances demand-based decisions (Korhonen, Huttunen and Eloranta, 1998). This can be accomplished through initiatives such as collaborative planning, forecasting and replenishment (CPFR) (Fliedner and Fliedner, 2007), vendor managed inventory (VMI), quick response system and efficient consumer response system (Caridi *et al.*, 2014).

4) Collaboration

Supply chain collaboration consist of many components such as;

a) Relationships and Partnerships: Close relationships and partnerships among supply chain partners is a key component to performance improvement (Sahay, 2003). A good relationship between the customer and supplier contribute immensely to reliable information flows across the supply chain (Heikkila, 2002). Through these relationships and partnerships, the moment a product leaves the shelf of a retailer, a notification is sent to the

manufacturer who in turn replenishes the product, and this is escalated upstream through the supply chain. (Lummus and Vokurka, 1999).

b) Information exchange: collaboration is a process that occurs when two or more organisations share the responsibility of exchanging information that enhance organisations' performance. The information shared should be relevant, timely and accurate (Barratt, 2004)

c) Participation: It represent the willingness of supply chain partners to use data from other members (Barratt, 2004).

d) Joint planning and decision making: The collaboration process involves the joint analysis of future demand and inventory status leading to joint collaborative planning and joint decision making. Notably, the joint collaboration planning actions influence the strength of relationships and the use of inter-organisational information systems in a demand driven supply chain (Hadaya and Cassivi, 2007).

e) Trust and commitment: dentified Trust can be clasified as reliability and benevolence.With reliability defined as the fufillment of obligations by supply chain partners and benevolence described as the interest of a supply chain partner in another organisation's welfare. The supply chain partner will not embark on unexpected action which might disadvantage the other partner.

f) Mutuality: It involves the sharing of both supply chain risk and benefits among supply chain partners (Barratt, 2004).

g) Openness and Honesty: culture of honesty is needed, for instance if there are any delays in delivery of products, the recipient should be notified early (Barratt, 2004).

5) Integration

Process integration and information systems integration also play a role in DDSCM;

a) Integration of Information and Decision support systems: Mbhele (2016) suggests that the integration of information systems and decision systems enables visibility along the supply chain. The more integrated the flow of information systems between supply chain partners, the easier it is to match supply and demand (Markham T Frohlich and Westbrook, 2002).

b) Process Integration: it involves the integration of *demand and supply processes. :* This includes the coordination of inter and intra organisational processes (Ho, Kumar and Shiwakoti, 2016). It also extends to agreements between supply chain partners on obtaining frequent small batch deliveries, long term contracts with suppliers and the adoption of technologies in transaction execution (Markham T. Frohlich and Westbrook, 2002) such as order placement and order management.

6) *Cross docking and Optimisation of distribution*

Demand driven supply chain management calls for responsiveness (Canever *et al.*, 2013). Cross docking is a distribution strategy that is supported by information systems. Inbound trucks deliver products to a warehouse and the products are quickly sorted and loaded to outbound trucks based on customer demands and routes without inventory being held in the warehouse (Buijs, Vis and Carlo, 2014). Optimization on distribution encompasses capitalization of other channel members' resources to improve responsiveness (Agrawal, 2012b) hence facilitating demand driven supply chain management.

7) *Lead time and lead-time gap*

Demand driven chains work better when the chains are short and well integrated (Canever, Trijp and Beers, 2008). Whenever possible, organisations have to move from long lead-times to short lead-times by optimising their processes. Another concept that can be utilised to enable DDSCM is the reduction of the lead gap by moving the customer order cycle closer to upstream operation through improved demand visibility.

8) *Organisational responsiveness and flexibility*

Organisational flexibility captures the organisation's ability to react through its operations to the changes in volume, product mix and schedule fluctuations (Hadaya and Cassivi, 2007). This entails that changes in customer demands can be efficiently fulfilled with changes in capacity, distribution plans and supply.

9) *Visibility*

The extent to which supply chain partners within a supply chain have access to or share real time data which they consider as useful and of mutual benefit (Barratt and Oke, 2007). Information on inventory level and customer demand must be transparent across the whole network (Budd, Knizek and Tevelson, 2012).

10) *Coordination*

Coordination among supply chain partners enables organizations to execute their operations effectively and efficiently (Budd, Knizek and Tevelson, 2012).

IV. SUPPLY CHAIN MATURITY MODELS

In an organization, maturity implies that processes are well comprehended, supported, monitored, documented and continuously improved (Fraser, Moultrie and Gregory, 2002). The origins of maturity models can be traced back to 1979 when a quality maturity grid was first developed (Crosby, 1979). The maturity grid provides a way of measuring and managing organizational processes according to five maturity stages; uncertainty, awakening, enlightenment, wisdom and certainty (Crosby, 1979). The quality management grid inspired the development of a capability maturity model (CMM) by the US Defense Software Engineering Institute (SEI) which provides a continuous software improvement path towards process capability (Netland and Alfnes, 2008).

There are common traits to all maturity models (Fraser, Moultrie and Gregory, 2002). They usually have: (1).Typically three to six maturity levels, (2). Each level has a generic descriptor, (3). Each level has a number of dimensions.

They are three types of maturity models; (1). Maturity grids, which involves textual descriptions of each activity for each maturity level. (2). Likert-like questionnaires or hybrid, which consist of a question or statement of best practices and the respondent is supposed to score on a scale from 1 to n, (3). CMM, these contain both generic and specific goals and key practices for each process area and maturity level (Mendes, Leal and Thome, 2016).

Table 5 in Appendix A2 outlines the literature review of SC-MM by scope, levels, architecture, typology and dimensions. It is interesting to note the diversity of the maturity models: supply chain management, demand driven supply chain, supply chain, supply chain flexibility, supply chain integration, logistics and supply chain collaboration. The number of maturity levels range between three and six and the levels are distinct depending on the scope of the maturity model. The architecture of the maturity models is either continuous or staged, with staged maturity models having a predominating frequency. With regards to typology, there is a high frequency of maturity grids, followed by hybrids and only two CMM-type because they are more complex. The dimensions of the SC-MM are also very diverse. However it can be noted that some of these SC-MM reviewed can be integrated into one holistic and comprehensive maturity model but no studies in supply chain management have made that attempt. Another important observation is that there is only one DDSCM-MM which is more oriented towards the upstream supply chain (manufacturing context) and does not take into consideration the activities of the downstream.

Also all SC-MM that were reviewed were tested if they satisfy all the design requirements for maturity models (Becker, Knackstedt and Pöppelbuß, 2009) as shown in Table 4 in Appendix A1. A high frequency of reviewed maturity models do not satisfy all the design requirements. The design requirements for maturity models consist of: (1) comparison with other maturity models prior to development of new or enhanced model, (2) follow an iterative procedure in model design, (3) model evaluation and testing in an organisational context, (4) multi-methodological approach, (5) identification of problem relevance, (6) problem definition, (7) the maturity model documentation.

The current supply chain related maturity models suggest that maturity starts at a basic level and progresses to a higher level of maturity. However, little emphasis is placed on the design of the ready-to-use and adaptable tools for maturity assessment and improvement. Notably, another view is that the dimensions of most of the maturity models can be integrated to produce a more consolidated maturity model.

This lead to the proposition of the development of the demand driven supply chain management maturity model. However it is the contention of this study to combine the relevant dimensions of reviewed SC-MM and DDSCM enabling factors into an integrated DDSCM-MM for the public healthcare supply chain in South Africa.

V. STUDY METHODOLOGY

The methodology for the development of the conceptual DDSCM-MM is based on literature review and synthesis of concepts.

Firstly, the DDSCM related papers are extracted from Scopus, web of science and emerald insight databases. The databases were meticulously searched with the following key words in the article title and abstract: ((Demand driven) AND (supply chain) AND ((visibility) OR (information sharing))). More than a thousand results were retained. Articles were screened based on the topic, abstract and the whole paper. Only 26 papers were selected and DDSCM enabling factors were identified from this dataset.

Secondly, Scopus database was searched with the following key words: "supply chain management" AND "maturity models". Only 56 papers resulted from this search. Papers were selected based on the topic and abstract. Also papers that were excluded from this study did not address the following: (1) they did not define the traits of MM as discussed in section IV (dimensions, activities, levels), (2) did not present a new model but quote an existing model, (3) only presented assessment methodology not a holistic maturity model and (4) they only focused on specific supply chain aspects such as supply chain human resources or supply chain risk. The reference of the resulting data set are mined and this results in only 13 papers with relevant SC-MM as shown in Appendix A2.

VI. CONCEPTUAL DDSCM-MM

For the identification of DDSCM-MM dimensions, we adopted the DDSCM enabling factors and grouped them into nine major dimensions; visibility, information technology, collaboration, inventory, delivery/ warehousing, customers, suppliers and procurement, human resources, and performance measurements as illustrated in Table 1. The demand driven healthcare supply chain dimensions are shown in Table 1. They capture the components of real time information flow through various technologies and platforms. This can be achieved through collaborative practices. Supply chain practices such as inventory management, distribution and warehouse management, customer orientation and segmentation are also chosen as dimensions. The human resources dimension is also important as it reflects the skills and experience of supply chain planning personnel. For continuous improvement to be effective there is need to have some performance metrics so that gaps of improvement can be identified.

Table 1: DDSCM-MM Dimensions

Dimension	Description
Visibility	Timely exchange of quality information with relevant supply chain partners.
Information Technology	Technologies that capture, analyze and distribute data. Also includes platforms and information systems integration
Collaboration	Collaboration encompasses, relationships, partnerships, information sharing, trust, mutually sharing risk, resources and rewards
Inventory management	The actions relating to management and control of inventory of healthcare products as it progress through the supply chain.
Delivery/Warehouse	Products receiving, products sorting and storage, quality management, dispatching and debriefing.
Suppliers/ procurement	Includes activities related to procuring goods and services to meet planned and actual demand. This dimension is also viewed as supplier relationship management.
Customers	Customer orientation and segmentation
Human resources	Describes the expertise required to perform planning tasks and manage processes such as skills, experience, aptitude and training needs. Aligning people and their skills to processes.
Performance measurement	The reference actions regarding to performance measurement for processes, human resources and activities

Following the common traits of maturity models, the DDSCM-MM consist of five stages for each dimension, indicating a descriptive name of each level and providing a description of what to anticipate at each maturity level. The stages are detailed in Table 2. Table 2 illustrates 5 stages adopted by the demand driven healthcare supply chain with first stage termed initial which represents ad hoc demand driven processes and it is proposed that as an organization progresses through the stages towards the highest maturity level termed optimizing, the processes become more established and focus now is placed on continuous improvement.

Table 2: DDSCM-MM Levels (Paulk *et al.*, 1993)

Stage	***Description***
Initial	The processes are very unpredictable and ad hoc. This represents the beginning point for use of a new process. However the process is not documented at this level.
Repeatable	The processes start to become disciplined. Documentation of processes to enable the repetition of the same steps may be attempted.
Standard	The processes become standardized and consistent. The processes are now well defined and confirmed as a standard organizational processes.
Managed	Quantified and predictable processes. The process is quantitatively measured and managed.
Optimizing	The focus is now on continuous improvement of the processes.

The maturity model in Table 3 was populated from literature review of SC-MM and DDSCM. Concepts from this literature review were integrated into a holistic conceptual DDSCM-MM. From the maturity model presented in Table 3, the nine maturity dimensions or process areas are appearing in rows and the maturity levels in columns. Maturity dimensions are key activities that when accomplished will result in an organization transition into a higher state of maturity while the maturity levels illustrate the evolutionary steps towards best practices in a healthcare supply chain.

Table 3: Conceptual DDSCM-MM

	Initial	*Repeatable*	*Standard*	*Managed*	*Optimizing*
Visibility	-No demand and inventory information flow. -Transactional information is static -High degree of manual intervention	-Inventory and demand information flow internally among organizational functions -Poor visibility of real customer demand -Process specific information is collected and shared within the organization	-Partial integration of internal data with external data -Information is collected and shared electronically with supply chain partners -Demand information is collected and shared with suppliers -Participation – willingness to use available information by supply chain partners	-Planning information exchanged among key partners enabling the development of partially joint plans -Full systems visibility from distribution through purchasing -Relevant information is automatically shared	-Real time end to end supply chain visibility -Supply chain improvement tools are effectively used -Integrated systems and internet – enabled systems allowing participants in the supply chain to view the same demand information simultaneously
Information technology	-Independent and incompatible planning, material control and purchasing systems -Different database systems -No integrated information systems -Heterogeneous spreadsheets existent and in use -Master data not accurately defined -No VMI and CPFR	-Isolated demand and supply planning systems with very limited scope of functionalities -No integration of demand and operations planning software -Planning systems do not have access to all relevant planning data -Inconsistent master data definitions -Master data not harmonized throughout the organization -Decentralized information storage -Pilot VMI and CPFR with supply chain partners	-Integrated planning and control system such as EDI to support the customer link and facilitate a faster response -Demand planning software with more advanced functionalities such as statistical analyses to generate sequentially optimized plans -Information from other systems need to be manually entered -Planning systems have access to most relevant planning data -Most master data consistently defined but not entirely harmonized throughout the organization	-Systems continuously keep track of plans and trigger automatically alerts in case of unexpected deviations -Software suggests resolution alternatives if required -Simultaneously/ real time feasibility analyses supported -Master data proactively managed internally but not externally -Decision support system -Integration of information systems	-Integrated and aligned IT systems with supply chain partners -Software supports CPFR, and other visibility tools to integrate supply chain partners in IT infrastructure -All relevant data (including capacities of third party providers) is available Master data consistently defined and harmonized throughout the supply chain -Automated communication
Collaboration	-No collaboration -Silo culture and low functional cooperation -Limited integration with supply chain partners -Ad hoc relationships -No efforts made to align supply and demand side plans	-Cross functional collaboration -Demand and supply planning processes are aggregated across the organization -Little attempt to develop supply and demand plans jointly -Intra organizational relationships	-Inter organization collaboration -Coordination, frequent exchange of information. -Synchronized flows and certain routine decision making processes	-Partnerships -Long term development of partners -Joint supply chain objectives -Strategic decision making -Trust and loyalty among partners -Openness and honest -Mutually sharing benefits and risks among supply chain partners -Integration of demand and supply processes	-Regular inter-firm collaboration -Connection of internal with external functions with all SC partners -Long term commitment -Supplier reduction -Technology exchange -Supply chain joint plans
Inventory	-Staged inventories caused by failure to integrate and synchronize activities - No formal standards for order management	-Functional formal order management	Internal formal order management	-Pull/demand flow inventory systems -Automated order management across units	-Order transaction and movement is visible to supply chain partners and customers

Delivery/ Warehousing	-Not customer oriented -Basic racks and forklifts -No layout reviews -No routing optimization	-Accurate inventories -Racking and double forklifts -Product Classification	-5S implemented, and owned by all -Training for all -Quality assurance in transportation and delivery of products	-Flexible layouts -Simulation tools -Triple and quad forklifts -Cross docking -Short lead time -Responsiveness and flexibility	-Outsourcing to maximize core competencies -Monthly reports to customers -Optimizing of distribution
Customers	-Customer satisfaction is low -Customer orientation not a priority -Incipient segmentation	-Customer satisfaction is improved but still low -Customer service tends to be reactive, the customer who shouts the loudest gets the goods -Identify strategic customers -Segmentation but not dedicated structure	-Customers are included in process improvement efforts -Customer satisfaction begin to show marked improvement -Reacting to customer demand rather than managing the customer -Customer policy	-Planning with customers -Customer policy linked to CPFR and VMI -Customer segmentation	-Customer base optimization
Suppliers and Procurement	-Supplier partnerships are not well defined -Transactional	-Identify strategic suppliers -Suppliers are monitored -Procurement integrated within functional areas -Defining policies to select and develop suppliers	-Strategic alignment with suppliers -Supplier skills development -Procurement policy	-Supplier relationship management established with some key suppliers -Collaborative activities with suppliers	-Advanced integrated IT with suppliers, second tier suppliers integrated -Supplier base optimization
Human resources	-Untrained personnel and no upskilling of staff taking place -Organizational roles and responsibilities not well defined -No assignment of roles and responsibilities with regards to planning tasks and activities -Insuffient planning know-how -No management commitment -No incentive for reaching targets	-Cross functional teams -No clear role descriptions -People not held accountable for their plans and performance -Little skills, aptitude and attitude of people towards planning -Insufficient management commitment and sponsorship -Structured training programmer being developed - Incentive plan in process of being developed	-Sufficient knowledge to perform planning activities -Planning responsibilities in place -Structured training programmer in place. -Staff is engaged in work based training and upskilling. -Management commitment and sponsorship - Incentive plan in place to encourage employees to reach targets.	-Planning is agile and enables fast response to unexpected changes - Staff is engaged in training where they attain a qualification by a recognized education body -Excellent management commitment and sponsorship -Success/ failure of employees being trained is measured. - Success/ Failure of incentive plan is measured.	-Employees and top management committed and strive for continuous improvement -The success/ failure of training programmers is analyzed -The training programmer is reviewed and optimized. - Incentive plan is optimized to get the best out of employees
Performance Measurement	-No KPIs in place to measure performance -No performance Tracking efforts made -Paper based reporting	-Basic KPIs defined -Some efforts of tracking performance -Reports are captured electronically for some aspects of the process	-Regular reporting and tracking of performance -Structural mechanism for performance evaluation -Reports are captured electronically for all aspects of the process	-Collaborative setting of real time performance targets -KPIs are measured and tracked to identify key improvement opportunities.	-KPIs consider the performance of supply chain partners and are aligned with payment modes -Internal and external benchmarking -Supply chain joint metrics -Corrective actions are taken when performance below expectations. Technology used to optimize performance tracking -Automated reporting

VII. CONCLUSIONS AND FUTURE RECOMMENDATIONS

The goals of this paper were to: explore the concept of DDSCM, determine the enabling factors of DDSCM, and compare current supply chain related maturity models and to propose a conceptual DDSCM-MM for the public healthcare supply chain in South Africa.

A conceptual demand driven healthcare supply chain management maturity model reflects a progressive path with regards to processes towards becoming demand driven. DDSCM consist of coordinated technologies and processes that facilitate the capturing, management and sharing of real time demand and inventory information across all supply chain partners. Some of the enablers of the DDSCM approach include, visibility, collaboration, ICTs, customer orientation, product classification, process integration, cross docking and optimization on distribution, reduction of the lead-time gap and organizational responsiveness. However, to be able to develop the maturity model we also had to review the current SC-related maturity models according to scope, levels, dimensions, typology, and architecture and also to test if they fulfil the design requirements of maturity models. It has been observed that little emphasis is placed on the design of the ready-to-use and adaptable tools for maturity assessment and improvement and another observation is that the dimensions of most of the maturity models can be integrated to produce a more consolidated maturity model. This led to the development of the conceptual demand driven supply chain management maturity model which is developed based on the integration of the relevant dimensions of reviewed SC-MM and DDSCM enabling factors.

Future recommendations include investigation of key improvement factors and tools that can be utilised by organisations in healthcare supply chain to move from one maturity state to another. Inco-operating these elements into the maturity model will make the maturity complete. The model in future needs to be validated through case studies and experts.

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Appendix A1

Table 4: Synopsis of Design Requirements of MM

Design Requirements	(Lockamy and McCormack, 2004)	(Mendes, Leal and Thome, 2016)	(Ayers and Malmberg, 2002)	(Lahti, Shamsuzzoha and Helo, 2009)	(Garcia Reyes and Giachetti, 2010)	(Vaidyanathan and Howell, 2007)	(IBM, 2007)
R1: Compare with other maturity models	Transfer of Business Process Orientation (BPO) MM to SCM and adoption of SCOR Processes	Comparison with other SCM maturity models	No comparison with other MM	Comparison with SC and logistics MM	Evaluation of enterprise reference frameworks, SCOR, and CMM	Review of SCM MM, CMM and other maturity models	No comparison with other MM. IBM also looks at management consultancy
R2: Iterative Procedure	Development of model from the principles of business process orientation	Dimensions and stages adopted from literature search. Then SC executives applied Analytical hierarchy process to assign priorities and rank the actual and desired dimensions	No complete description of how the dimensions and stages of MM are chosen	Development of a new model using a model developed by PMG and PRT management consultants as a development guideline	Literature search to determine structure of a MM then use of Delphi study to identify dimension, stages, improvement tools and factors	Conceptual model developed based on the concepts of process maturity.	Survey instrument used to collect data on what leading companies are doing
R3: Evaluation	Survey instrument to investigate SCM process maturity and overall supply chain performance	Tested in a large beverage company in three different countries	MM is not tested	Application of model in a case company	Validation with experts	No validation	Application of model in a manufacturing organization and logistics , customer order management as well
R4: Multi-methodological approach	Literature Search, survey instrument	Literature search, experts, case study	Literature search	Literature search, case study	Literature search, Delphi method, experts, case study	Only Literature review	Only experts through a survey instrument
R5: Problem Relevance	No published studies which examine the concept of process maturity relative to SCM	No framework that combine dimensions of demand driven supply chain of Ayers (2002) and Lambert (2008) supply chain processes	Many obstacles to complex Supply chains Improvements and some initiatives fall short of objectives	A supply chain strategy for the visibility of supply and demand collaboration determines the success of a firm	Lack of guidelines in SC assessment and improvement. Also existing models are theoretical constructs and not tested with actual Supply chains	Construction industry is still in infancy but however other maturity models such as CMM cannot be applied directly to guide in the development of the industry	As supply chains evolve from static to demand driven other companies are striving to meet their objectives and there is room for improvement but developing top supply chains is hard
R6: Problem definition	SC process MM that can be used to help facilitate enhanced SC performance	Frame work for assessment of organization current DDSC maturity levels and helps in the development of a roadmap to set SC strategies	Framework showing how supply chain organization and demand driven supply chain can support the introduction of information technology to SC	A framework for organizing disparate supply chain efforts around business processes, tools and standards	Framework that can evaluate their current supply chains and develop an improvement roadmap. Highlights the best practices that a company should focus on in improving.	Framework to be used to asses processes, technologies, strategy and value in construction industry and provide a roadmap towards operational excellence.	Framework for describing how different supply chains for organizations address challenges for different supply chain process areas
R7: Publication	Journal Paper	Journal Paper	Journal Paper	Journal Paper	Journal Paper	Conference Paper	Report

Continued…

Design Requirements (DR)	(Fischer *et al.*, 2016)	(Stevens, 1989)	(McLaren, 2006)	(Battista, Fumi and Schiraldi, 2012)	(Ho, Kumar and Shiwakoti, 2016)	(Stonich and Moncrieff, 2001)
R1: Compare with other maturity models	Recognizes MM such as quality maturity grid, CMM, BPO, SCOR, SCM	No comparison with other existing maturity models. Model developed by consultancy firm.	Comparison of existing supply chain models. The model integrate two dominant supply chain maturity models	Stages of the logistics maturity model are developed from the Capability maturity model integration	Model developed based on capability maturity model integration approach	Not specified
R2: Iterative Procedure	No complete description of methodology used for the development of the MM and how the dimensions and stages are derived	No methodology specified for the development of the MM.	Integration of two maturity models into one	No clear methodology explained that was used to develop the logistics maturity model	Only adopted the CMMI approach and used literature search on collaboration to populate the model	Not specified
R3: Evaluation	The model is applied in a toy case in the automotive supply chain	The model is not applied	Case company	The model is not applied in any supply chain settings	The MM is not tested	Applied in a discrete electronic equipment sector
R4: Multi-methodological approach	Literature review and case study in a toy case automotive supply chain	Literature review	Case study, interviews and questionnaires	Literature review only	Literature review only	Case study
R5: Problem Relevance	Currently, there is a gap in literature for models that measure the maturity of supply chain flexibility	Supply chain issues such as lead-time, inventory levels, availability caused by conflicting functional goals and attitudes can be resolved by an integrated supply chain, therefore there is need of a supply chain strategy to ensure a structured approach to supply chain integration	Despite apparent benefit of web-enabled supply chain integration , its further study and application is hindered by the lack of empirically supported model for classifying the varying levels of supply chain integration that are now possible using e-business technologies	There is lack of an easy to use framework, hard criterion of process modelling and evaluation of maturity and lack of framework that in cooperate global vision of business logistics processes	There is lack of clear theoretical framework which guides organizations in implementing or improving the collaboration maturity level for a supply chain	It is vital that organizations determine their strategic intent in leveraging their supply chain and implement best practices to enable improvements
R6: Problem definition	Model to measure the maturity of flexibility in inter-organizational supply chains	Model to guide organizations towards an integrated supply chain	Framework to assess the level and integration dimensions including supply chain strategy ,performance management and decision making	Model to support the enterprises to understand immature processes, improvement actions.	Framework to analyze collaboration practices in organizations and develop a roadmap towards advanced collaboration in supply chain	Model describing stages of operational capabilities within a supply chain and providing a roadmap for improvement
R7: Publication	Conference paper	Journal Paper	Conference Paper	Conference paper	Conference Paper	Report

Appendix A2

Table 5: Comparative analysis of SC-MM

Reference	*Satisfied Design Requirements*	*Scope*	*No. of levels*	*Level Descriptors*	*Architecture*	*Typology*	*Dimensions*
IBM (2006)	R2,R7	SCM	5	Static, functional, horizontal integration, external collaboration, demand driven	Staged	Grid	3 key areas; Information flow, organisational structure, order management
Mc Laren (2006)	Satisfy All	SCI	5	Functional focus, internal integration, linked network, integrated network, optimised network	Continuous	Grid	4 focus areas; Organisation structure, performance measurement, collaboration
Stevens (1989)	R7	SCI	4	Baseline, functional, internal integration, external integration	Continuous	Grid	7 focus areas; Supply chain planning, organisational structure, customers, information flow, performance metrics, planning technologies and collaboration
Battista et al. (2012)	R1, R5, R6, R7	LMM	5	Start-up, managed, defined, measured, optimised	Continuous	Grid	4 focus areas; procurement, plan, distribute, storage
Moncrieff and Stonich (2001)	R5, R6, R7	SCM	4	Functional focus, internal integration, external integration, cross enterprise collaboration	Staged	Grid	11 focus areas; plan, source, make, deliver, overall, information flow, information sharing, information technology, resources, performance measurements, partnerships and collaboration
Lockamy & McCormack (2004)	Satisfy All	SCM	5	Ad hoc, Defined, Linked, Integrated, Extended	Staged	CMM	6 Focus Areas; suppliers, customers, source, make, deliver, plan
Mendes et al., (2016)	Satisfy All	DDSC	5	Basic push, optimised push, hybrid push-pull, advanced demand driven, optimised demand driven	Continuous	CMM	3 main focus areas: Demand management, Supply and operations management, Product Lifecycle management
Reyes and Giachetti (2010)	Satisfy All	SC	5	Undefined, defined, manageable, collaborative, leading	Continuous	Hybrid	7 Focus areas; suppliers, customers, production, inventories, human resources, information systems and technology, performance measurement systems
Lahti et al., (2009)	R1, R2, R3, R4, R6, R7	SCM	4	Functional focus, internal integration, external integration, cross enterprise collaboration	Staged	Hybrid	7 focus areas; Supply chain processes, information flow, organisational roles and responsibilities, supplier and customer partnerships, performance measurements, resources
Fischer et al., (2016)	Satisfy All	SC Flexibility	5	No flexibility, intra-firm flexibility, reactive flexibility, proactive flexibility, paradigmatic flexibility	Continuous	Grid	5 focus areas; collaboration, information flow, information technology, internal flexibility types, performance measurement
Ayers (2002)	R5, R6, R7	SC	4	Infrastructure, cost reduction, collaboration, strategic	Staged	Grid	4 focus areas; supply chain organisation, demand driven supply chain, supply chain systems, stage challenges
Vaidyanathan & Howell (2007)	R1, R2, R5, R6, R7	CSCM	4	Ad hoc, defined, managed, controlled	Staged	Hybrid	Project management, collaboration, information flow, planning , automation
Ho et al., (2016)	R1, R5,R6, R7	SCC	5	Initial, managed, defined, quantitatively managed, optimizing	Staged	Grid	15 focus areas including, Information sharing, goal congruence, decision synchronization, incentive alignment, resource sharing, collaborative communication, managerial support, internal alignment, relationships