INCORPORATING PRODUCT CATEGORIZATION TO IMPROVE THE PERFORMANCE OF SA'S PUBLIC HEALTHCARE SUPPLY CHAIN: A RESEARCH AGENDA.

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ABSTRACT

In an influential publication from the late 1990's, Marshall Fisher argued that many of the challenges in supply chains could be traced back to a lack of alignment between the type of product and the type of supply chain. Subsequently, the idea of tailoring supply chain management practices and policies to the characteristics of the products being supplied has received significant research attention, and various researchers have worked on modifying the premise as well as on its application to diverse sectors, with promising findings.

The South African National Department of Health is in the process of rolling out the Visibility and Analytics Network (VAN) reference framework, with the aim of ensuring sustained availability of and access to commodities. At present, the VAN strategy does not incorporate a product categorization element. This paper proposes a research agenda for determining how product categorization could be incorporated into the VAN strategy to enable supply chain practices and policies to be tailored to the characteristics of products.

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1.   INTRODUCTION: BACKGROUND

Supply chains incorporate the end-to-end streaming of information, products, and money [1]. Consequently, how supply chains are managed has significant implications for an organization's competitiveness in the context of product cost, working capital requirements, lead time to market and service delivery, among others [1]. Supply chain management is therefore defined as:

> *"the management of upstream and downstream relationships with suppliers and customers in order to deliver superior customer value at less cost to the supply chain as a whole"* [2].

In this setting, the appropriate alignment of the business strategy with the supply chain is critical to achieving a high level of business performance. Harris, Componation and Farrington [3] added by stating that a product with steady demand and dependable supply cannot be managed similarly as a product with unpredictable demand and inconsistent supply. Fisher [4] proposed that the reason why supply chains do not perform as expected despite increased investments in effort and resources is improper alignment of product attributes and supply chain strategies.

The South African National Department of Health (NDoH) is in the process of rolling out the Visibility and Analytics Network (VAN) reference framework, with the aim of ensuring sustained availability of, and access to, medicines [5]. One of the objectives of the VAN strategy is to transform South Africa's public healthcare pharmaceutical supply chain from an 'uninformed pull' system, to an 'informed push' system; the distinction between these respective systems being that specialized supply chain management professionals will be utilized in each province. These respective professionals will analyse and optimize complex links in the public healthcare pharmaceutical supply chain and make inventory planning and management recommendations to primary healthcare facilities (PHCF), rather than the PHCFs doing it on their own [5]. An informed push model will relieve the PHCFs staff of sophisticated and time-consuming supply chain planning work and enable them to focus more on delivering healthcare.

At present, the VAN strategy does not incorporate product categorization—which entails the organization of products into categories according to shared attributes; more specifically, when supply chains are considered, attributes that are related or could influence the best supply chain management strategy for said attributes [6]. Simchi-Levi, Clayton and Raven [7] reasoned that "one size does not fit all" in the formulation of a supply chain strategy highlighting the fact that different supply chain management strategies are most likely needed for products with varying attributes. Various products (e.g. anti-hypertensive, anti-viral, thrombolytic and anti-cancer medicines etc.) [8] require different supply chain management strategies (e.g. continuous-flow, efficient, fast, agile supply chains etc.) [1] depending on the product attribute context (e.g. demand volume, lead-time, uncertainty, life cycle etc.) [9]. Findings from a survey conducted by the Stop Stock-outs Projects (SSP) stated that in 2013, 21% of South African public healthcare facilities experienced a stock-out or shortage of a Tuberculosis (TB) or Human Immunodeficiency Virus (HIV) medicine within three months prior to SSP conducting the survey [10]. In 2014, a second national SSP survey exposed that the abovementioned percentage further increased to 25% meaning that a quarter of public healthcare facilities in South Africa experienced HIV and TB medicine stock-outs within the three months prior to the SSP survey. In 2015, the status quo remained unchanged [11]. The product categorization concept therefore proposes that such essential medicines should have separately managed supply chain strategies due to possible severe risks associated with non-availability of medicines such as the interruption of treatment of chronic diseases patients which poses a risk of developing drug resistance [10].

Alignment of product attributes with the appropriate supply chain strategy has benefits for the organization that go well beyond the positive effects on cost, efficiency, productivity and competitiveness [1]. Payne and Peters [12] added to Fisher's framework of product classification ascertaining that "no matter how good the supply chain characteristics are, if the product fundamentally does not fit with the dominant supply chain design, optimum service and cost cannot be achieved". Research has quantitatively analyzed and explored the validity of Fisher's framework for improving efficiency, applying the concept in a wide range of sectors like the electronic commerce, fashion industry, manufacturing industry and wine industry, which are elaborated in section 3.1.

In terms of the benefits of product categorization for the healthcare sector specifically, Prinja, Bahuguna, Tripathy and Kumar [8] proposed that the concept of product categorization poses benefits in sustainable availability of medicines and reduction in healthcare expenditure, while others have highlighted that it is vital to business attributes such as spend analysis, financial analysis, strategic sourcing, tendering, enterprise resource planning, and merchandising in healthcare [13]. Product categorization has come as a concept to be employed in conjunction with robust Information Technology (IT) systems for better use in scientific warehousing

and inventory management, transparent integrated procurement, real-time stock monitoring, and decentralised distribution methodologies [8].

Effective application of the concept of product categorization into the South African pharmaceutical supply chain has the potential of reaping the same or more benefits as established in other industries. This paper aims to propose a research agenda for determining the viability and value of incorporation of product categorization in the South African public healthcare pharmaceutical supply chain. The focus will be on the feasibility of tailoring the supply chain practices and policies to the attributes of products within the said context. To establish the said aim, the first objective of providing an overview and trends in research of product categorization dimensions as applied in other industries and then more particularly the healthcare sector was established. Furthermore, product categorization dimensions were defined through determination of product attributes in relation to supply chain strategies.

2. METHODOLOGY

To understand the trends in research, the current applications of product categorization, and how product categorization relates to supply chain strategies, a systematic literature review was conducted. The systematic literature review consisted of firstly gathering and then analyzing research studies and publications concerning product categorization and supply chain strategies that incorporated the practice of product categorization. An overview of the application of product categorization dimensions across industries and more specifically healthcare sector are subsequently provided.

2.1 Systematic literature review methodology

The literature review was conducted using the Scopus[1] database to identify the application trends of product categorization. The literature review thus sought to address the following research questions (RQ):

❖ RQ 1: For the past decade (2007 to 2017), what have been the trends and concepts employed in applying the product categorization dimensions?
❖ RQ 2: What are the impacts of incorporating product categorization in the various industries?

Both research questions are considered within a supply chain management context. Keywords from the research questions were derived and a Scopus database search was conducted, and the search line (which also catered for variations between American English and British English where 'z' can be used for 's'; as well as word variations for instance: 'distribute', distributary' and 'distribution' etc.) was developed. The search line also took into consideration the understanding that product categorization, segmentation or classification are used interchangeably in literature as synonyms. Since the aim is to consider product categorization within the context of supply chain management, the terms 'supply chain' and 'value chain' are also included as search terms as well as 'demand', 'supply' and 'distribution'. Supply chain and value chain do not necessarily mean the same in literature, but they have various aspects that intersect hence the two in context were incorporated in the search line.

The aim is to understand the contemporary concepts and impacts of the application of the concept of product categorization, and therefore the literature available over the past decade (2007-2017) was considered in the Scopus database search. The search line that was used to identify relevant literature is as follows:
 (((categori* OR segment* OR classif*) W/5 (demand* OR supply* OR distrib*)) AND ("supply chain" OR "value chain")).

The search field included the article title, abstract and keywords. The initial search, that was not limited by publication year, yielded 792 documents. The search line used was then limited to the publication years 2007 to 2017 (consistent with the research question of finding the focus of research on product categorization for the past 10 years) and yielded 636 documents. In screening the 636 documents for relevance; two criteria were used:

    i.   Firstly, documents that addressed the development of frameworks and models of product categorization dimensions and/or supply chain strategies were accepted (documents that referred to product categorization once were part of the search results; however, they were not related to developing frameworks and models for product categorization, so they were screened out),

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ii.   Secondly, documents that at least detailed how and why the aforementioned dimensions and strategies should be applied in any setting were included too.

Furthermore, a review was done into whether the frameworks and models in the different sectors were developed from parameters related or applicable to supply chain strategies and those that satisfied this question were accepted. After the titles together with the abstracts of the 636 documents were reviewed for relevance using the above stated criteria, the screening yielded 61 documents that were concerned with detailing and/or development of frameworks, models and impacts of incorporation of product categorization and/or supply chain strategies. Care was taken not to perform extensive filtering of the documents lest important documents might be left out. This meant a set of documents totalling 61 publications were scrutinized. Four documents were found to be inaccessible and this gave a remaining total of 57 documents. Seven documents from references of the 57 documents that were significantly referenced by authors and satisfied the above stated criteria were incorporated in the systematic literature review and gave a total set of 64 relevant documents. A summary of the approach followed is provided in Figure 1.

To fully pursue the aim of proposing a research agenda for the incorporation of the product categorization concept in the South African pharmaceutical supply chain, an overview of the application of the concept in other industries as well as the healthcare sector is considered. This will facilitate the understanding of the impacts of incorporating product categorization in the various industries found in literature and these insights can be used to develop suggestions on how these impacts can possibly be applicable to the South African pharmaceutical supply chain. A framework established in 1997 by Fisher [4], an acknowledged pioneer in the linking of supply chain strategies with product attributes will then be used to define the dimensions of the product categorization concept, consistent with the second objective of this paper. Existing product categorization methods (product characteristics attributes and the categorization selection methods) which premised on Fisher's framework are used as basis for this proposition.
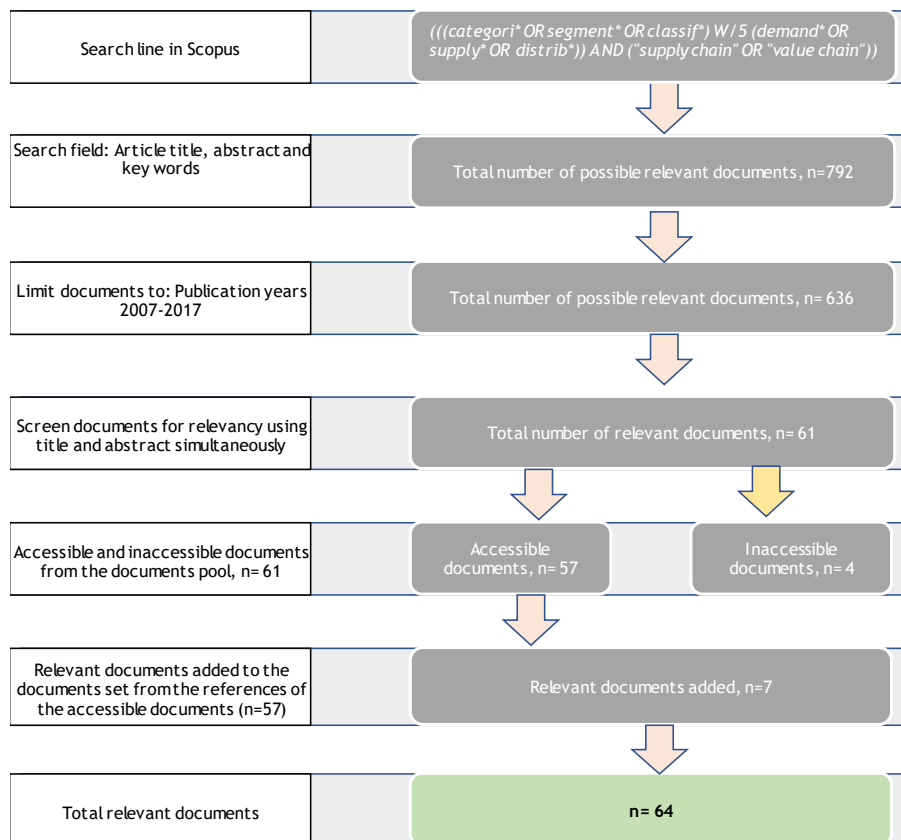

Figure 1: Scopus database search methodology

3. OVERVIEW OF PRODUCT CATEGORIZATION APPLICATION

This section provides an overview from the systematic literature review of the application of the product categorization concept, firstly in other industries which are not healthcare (where there were 18 industry-application specific documents from literature), then secondly in the healthcare industry itself (where there were three industry-application specific documents from literature). This section is consistent with the two aforementioned research questions as well as the first objective of this paper.

3.1 Application in other industries (not healthcare)

The concept of product categorization has been applied in a wide range of industries, but for this paper the manufacturing industry, fashion and retail industry, E-commerce industry and wine industry have been chosen for analysis. This is because it has been understood that the nature of the industries' supply chains shares certain characteristics with the healthcare supply chain, including:

✓ Agility to seasonal and demographic variations, in the case of the fashion industry;
✓ The visibility, variability, analytics and categorization of a large innovative product portfolio and how they are supplied that underscores the need for continuous improvement, in the case of the e-commerce industry;
✓ Responsiveness to high demand, especially in the case of the wine industry; and
✓ Combination of lean and agile principles, in the manufacturing industry.

Table 1: Impacts of application of product categorization in selected industries

Industry	Literature	Concepts in application	Impacts
Wine industry	Wen et.al [14]	Quality Function Deployment (QFD)	Product management, transport and package management and marketing.
Manufactu-ring	Nagashima et.al [15]	Ordered feature evaluation analysis (OFEA). Collaboration intensity.	Demand forecasting accuracy
	Naim et.al [16]	Lean and agile paradigms giving 'Leagile' manufacturing	Optimal determination of decoupling point
	Ramkumar et.al [17]	Vendor Managed Inventory (VMI)	Reduction in lead time and demand variability. Optimal stocking quantities at warehouses
	Ervolina et.al [18]	Available-To-Sell (ATS)	Optimal demand forecasting. Profitable demand response. Profitable product portfolio.
	Hiremath et.al [19]	Outbound logistics network (OLN). Multi objective genetic algorithm (MOGA)	Minimize the total network cost. Maximize resource utilization
	Taylor et.al [20]	Concurrent product and supply chain design (CP-SCD)	Provide managerial insights in design trade-off analysis
	Li [21], Fichtinger et.al [22]	Two-Echelon Dual-Channel Supply Chain	Development of profitable market segments
	Micieta et.al [23]	Group technology	Improvement in quality, productivity and inventory management. Increase costing accuracy. Increase customer service. Reduction in overall production times. Gain in sustainable competitive advantage
	Rajan and Wang [24]	Hierarchical clustering	Obsolescence Reduction

Fashion industry	Sen [25]	Efficient supply chain management practices	Production of a variety of sizes, styles and colors in shorter lead-time. Agility to changing demand requirements. Ability to better forecast
	Roscoe and Baker [26]	Supply chain segmentation	Aligning of demand planning, marketing, sales and supply chain functions.
	Martinez et.al [27]	Pronto Moda or Rapid-Fire Fulfilment	Reduction of variety and wide range of garments per collection. Standardizing fabrics and product platforms. Introduction of mini-collections
	Sardar et.al [28]	Outsourcing strategies. Goal programming	Cost saving. Capacity flexibility
E-commerce	Rofin and Mahanty [29]	Cournot model	Determination of optimal product categories' dual-channel supply chain configuration for different customer online channels preference
	Hofbauer et.al [30]	Ontology	Derivation of web ontologies. Efficient and reliable electronic product data exchange across organizations.
	Liao et.al [31]	Two-step data mining approach	Mining customer knowledge on online channels and product segments preferred. Better market segmentation

From the systematic literature review conducted, these areas have received significant attention. Product categorization has had various impacts to these industries which are in the context of demand planning, distribution planning, forecasting, supply planning; and more specifically in product value, product shelf space, lead time, demand variability etc. Table 1 above details the concepts of product categorization application in the industries and the impacts of these.

Deducing from the selected wine industry, it can be understood that responsiveness to high demand peaks is potentially feasible through the incorporation of product categorization with positive impacts. As information about product categories (volume, volatility of ordering or value) becomes available, informed decisions about sourcing and outsourcing (local or international) of medicines can possibly be made. With delivery frequencies and minimum lot sizes determined, the cost on inbound and outbound transportation can potentially be reduced [14].

Examples from the manufacturing industry show that optimal determination of decoupling point, reduction in lead time and demand variability, optimal stocking quantities at depots and demand forecasting accuracy are dimensions that can possibly be achieved by the incorporation of product categorization. As seen in the fashion industry, a reduction of variety and wide range of garments per delivery as well as standardizing product platforms is potentially possible through the incorporation of product categorization. Mini-collections and supply flexibility are likely to be achieved too. The E-commerce industry shows that visibility, analytics and categorization of a large product portfolio is likely feasible through the incorporation of product categorization. Determination of optimal product categories' multi-channel supply chain configuration for products is potentially possible as well.

3.2   Application of product categorization in healthcare

Unlike in the commercial sector where the focus is largely on profit and competitive advantage, the healthcare sector poses a different configuration in that it mainly focuses on effective and sustainable availability and administration of healthcare [32]. The application of product categorization in literature in healthcare is summarized in Table 2.

Table 2: Impacts of application of product categorization in healthcare

Industry	Literature	Concepts in application	Impacts
Healthcare	Yadav et.al [33]	Vaccines supply chain generic map	Efficient, effective and sustainable delivery of vaccines to end recipients.
	Hua et.al [34]	Integrated reverse supply chain model	Increase in percentage of unexpired medications grew, the rate of expired medications collection remained the same but the profit of the whole reverse supply chain increased. Cost reduction.
	Kritchanchai and Meesamut [35]	Inventory management model	Minimized total inventory costs while maintaining drug administration safety levels. Reduction in demand variability. Increase in demand forecasting accuracy.

The concept of product categorization has been used in the healthcare sector by Yadav, Lydon, Oswald, Dicko, and Zaffran [33] in developing a framework for decision making in the integration of vaccine supply chains with other health commodities supply chains. The framework enabled the optimization of immunization supply chains as vaccines were delivered to the end recipients efficiently, effectively and sustainably. Optimal product categories which aided in aligning of demand planning and supply chain functions were determined. Hua, Tang, and Wu [34] employed the product categorization concept in developing an integrated reverse supply chain model. The model was meant to investigate the impact of various unwanted medications categories and government's publicity and penalty investment on the reverse supply chain profit as well as collection rate of expired medications. The findings showed that as the percentage of unexpired medications grew, the rate of expired medications collection remained the same, but the profit of the whole reverse supply chain increased [34]. There was a significant reduction on cost as well. Kritchanchai and Meesamut [35] employed the concept in developing an inventory management model for a hospital in Thailand. They argued that a single inventory management system could not be used on all medicines effectively. The inventory management system they developed, which incorporated the product categorization concept, enabled the hospital to minimize the total inventory costs while maintaining patient drug administration safety levels. Provision for demand forecasting accuracy was made as well as reduction in demand variability [35].

The application of product categorization, as seen in other industries (section 3.1) and the healthcare industry (section 3.2), can be used to suggest possible impacts of application of product categorization in the South African public healthcare pharmaceutical supply chain (section 3.3).

3.3   Possible impact of product categorization in the South African public healthcare pharmaceutical supply chain

As seen in the industries discussed in section 3.1 and 3.2, the incorporation of product categorization in the South African public healthcare pharmaceutical supply chain can potentially reap positive results. Product categorization will potentially enable determination of optimal lot sizes for various pharmaceutical products, replenishment frequency and safety stock levels for different product categories. The lower the replenishment lead time from the provincial depots, the lower the amount of safety stock that needs to be held by the PHCFs. Product categorization has the potential to aid in ensuring sustainable availability of pharmaceuticals. Some products are highly sensitive to shortages and stockouts and these pose an excessive cost to both the healthcare system and its patients, thus on-time performance, which also affects the variability of lead time, will possibly be optimized by the incorporation of product categorization. Product categorization in the South African public healthcare pharmaceutical supply chain has the capability of increasing supply flexibility of various pharmaceuticals. The more flexible the supply is, the less lead time variability will be potentially displayed as order quantities. Product categorization based on product attributes (demand, value volatility etc.) will possibly enable a better match between demand and supply chain strategy (continuous-flow, efficient, fast, agile supply chains) to ensure sustainable medicine availability. The incorporation of product categorization in the South African public healthcare pharmaceutical supply chain will potentially enhance the design collaboration capability for demand planning, supply planning and distribution planning and this will possibly decrease required inventories and transportation costs.

Sections 3.1, 3.2 and 3.3 have detailed the impacts of the concept of product categorization when applied in various industries including the potential benefits product categorization can have in the South African public healthcare pharmaceutical supply chain. Section 4 below will detail how product categorization has been generically conceptualized.

4. CONCEPTUALIZATION OF PRODUCTION CATEGORIZATION

This section seeks to define product categorization dimensions through the analysis of product attributes in relation to supply chain strategies consistent with the second objective. It endeavors to bring to the topical discussion of the concept of product categorization in general (i.e. non-industry specific). Supply chains in various industries suffer from an excess of some products and a shortage of others due to an inability to effectively predict demand [3]. According to Fisher [4], the root cause of the problems such supply chains face is a mismatch between the product-type and the supply chain-type. As shown in Figure 2, Fisher [4] proposed that if products are classified based on their demand configurations, they fall into one of two categories: they are either primarily functional or primarily innovative. Furthermore, Fisher [4] proposed that supply chains can either be physically efficient or market responsive. These concepts are explored in more depth in the remainder of this section.

	Functional Products	Innovative Products
Efficient Supply Chain	Match	Mismatch
Responsive Supply Chain	Mismatch	Match

Figure 2: Fisher's framework, matching supply chains with products. (Reproduced from [4].)

4.1 Functional and Innovative Products

Functional products are the widely available products which satisfy basic needs. They are characterized by a relatively extensive life-cycle, with little change over time and little variance in their offerings [3]. Demand for functional products is typically predictable and stable, and they tend to possess low profit margins because of the many competitors in the market [2]. Inventory is used to buffer demand because the cost of obsolescence is low.

Sullivan et.al [5] highlighted that innovative products are typically distinguished as trendy and have highly volatile demand that is difficult to predict. They are associated with significantly more uncertainty than functional products [4]. Innovative products have larger product variety and short life-cycles, but the profit margin is high, therefore lost sales (opportunity cost) exert a significant effect on company performance [3]. Table 3 shows the demand aspects for classification of products as either functional or innovative.

Table 3: Product demand aspects versus functional or innovative (adapted from [4].)

Demand Aspects	**Functional** (Predictable Demand)	**Innovative** (Unpredictable Demand)
Average stock-out rate	1% to 2%	10% to 40%
Product Variety	Low (10 to 20 variants per category)	High (often millions of variants per category)
Contribution to Margin	5% to 20%	20% to 60%
Product Life Cycle	more than 2 years	3 months to 1 year

Various products from the pharmaceutical product portfolio can probably be determined and categorized according to either being functional or innovative. This, as established by Fisher [4], would be dependent on the pharmaceuticals demand aspects (e.g. average stock-out rates, product life cycle and product variety etc.) of each product. It can then be reasoned that chronic medication which has a stock-out rate of 25% as established in section 1.0 above, will not be considered the same as other medication with little or no stock-outs. Chronic medication stock-outs can probably be argued to be in the innovative products category since their stock-out rate is between 10% and 40% as identified in Table 3. However, it can contrarily be argued that since normally chronic patients are registered and known, then chronic medication should have predictable demand and thus should be categorized as functional. This uncertainty in categorization brings the need to consider all chronic products attributes, and this is the aim of this research agenda.

4.2 Physically Efficient and Market Responsive Supply Chains

Innovative products with their high profit margins and volatile demand, require an essentially different supply chain than stable and low-margin functional products [3]. According to Fisher [4], two supply chain types—physically efficient and market responsive—exist [4].

Physically efficient supply chains' fundamental focus is cost reduction and the efficient use of resources. Sullivan et.al [5] emphasised that this type of supply chain pursues creation of the lowest possible cost of operation through the removal of all non-value adding activities, chasing economies of scale and optimizing resource utilization. As shown in Figure 2, Fisher [4] proposes that companies that offer functional products should employ an efficient supply chain.

In contrast, the market responsive supply chain is fundamentally focused on meeting the customer delivery expectations irrespective of demand variability. As shown in Table 4, Fisher [4] proposes that market responsive supply chains are most appropriate for innovative products. The possibility of a stock-out increases when product demand is uncertain and volatile [4]. Lee [36] also asserted that supply disruption risks are mitigated in market responsive supply chains by the strategic placement of inventories and thus such a supply chain can adapt to customer, market, and supply uncertainty. Table 4 details the physically efficient and market responsive supply chains attributes.

Table 4: Physically Efficient and Market Responsive supply chains (adapted from [4].)

	Physically Efficient	Market-Responsive
Primary Purpose	Supply predictable demand efficiently at the lowest possible cost	Respond quickly to unpredictable demand to minimize stock outs, forced markdowns, and obsolete inventory
Inventory Strategy	Generate high turns and minimize inventory throughout the chain	Deploy significant buffer stocks of parts or finished goods
Lead-Time focus	Shorten lead time if it does not increase cost	Invest aggressively in ways to reduce lead time
Product-design Strategy	Maximize performance and minimize cost	Use modular design to postpone product differentiation for as long as possible

Given the above discussion, it is proposed that the South African public healthcare pharmaceutical supply chain could potentially benefit from aligning various pharmaceutical products to various supply chain strategies. Therefore, the concept of fitting supply chain strategies to the demand attributes of pharmaceuticals to ensure sustainable availability of medicines should be investigated.

4.3 Generic supply chain models

Perez [1] defined six generic supply chain models, grouped into two clusters that align to the types of supply chains defined by Fisher [4]. Three of Perez's [1] generic supply chains are oriented to achieve physical efficiency and three are oriented to achieve market responsiveness.

The three physically efficient supply chain models defined by Perez [1] are:

❖ *Continuous-flow supply chain*: This supply chain employs a 'make to stock' decoupling point where production is scheduled to replenish predefined stock levels which are based on a specific reorder point for inventory in the production cycle. It pursues high service levels and low inventory levels. It is mainly proposed for businesses with short shelf-life products, for example bread and dairy products.
❖ *Efficient supply chain*: This supply chain has production scheduled based on sales expectations for the duration of the production cycle, using a 'make to forecast' model as a decoupling point. It has been proposed for businesses with commoditized products, for example cement and steel.
❖ *Fast supply chain:* This supply chain has production scheduled in a single batch per stock keeping unit (SKU), with the size being defined by the season's sales expectations, and utilizing a 'make to forecast' decoupling point. The fast supply chain has been proposed for companies that engage in catalogue sales and trendy apparel for example fashion clothing.

The three market responsive supply chain models defined by Perez [1] are:

❖ *Custom-configured supply chain*: This supply chain is characterized by multiple configurations of the finished product on a unique platform, using a 'configurable to order' decoupling point. The custom-

configured supply chain has been recommended for assembly of personalized products, for example computers and vehicles.

❖ *Agile supply chain:* This supply chain employs a 'make to order' decoupling point, where items are produced after a purchase order has been placed by the customer. It has been proposed for businesses that are characterized with unpredictable demand and essential for companies that use unique specifications for each customer to manufacture products for example chemical specialties and packaging.

❖ *Flexible supply chain:* This supply chain is characterized by adaptability, which entails the capability to reconfigure internal processes to meet a specific need (or solve a problem) of a customer. It is mainly proposed for service companies that encounter unexpected situations and emergencies faced with long periods of low workload and high demand peaks for example the medical emergency response sector.

Different products in the healthcare pharmaceutical industry can probably fall into each of these six generic supply chain models and thus need to be treated differently. Aligning each pharmaceutical product category with each supply chain model has the potential to optimize performance of the pharmaceutical supply chain and possibly enhance sustainable medication availability.

4.4   Product Categorization Methods

Over the years, numerous categorization methods using various product attributes have been developed for various sectors, whether manufacturing or e-commerce or distribution logistics. For several of them, the difference in the product attributes used is basically on semantics but in concept being the same, for example one would use 'flexibility' and the other would use 'agility' basically addressing the same concept. Perhaps the most salient product attributes definition is the one proposed by Sullivan et al. [5] which also details the measurable characteristics of the products attributes. Examples of these product characteristics include demand, cost, quality, lead-time, life-cycle, and the level of certainty with regards to customer demand and the market environment. The complete set of product characteristics defined by Sullivan et al. [5], together with the measurable attributes that have been defined for each, are presented in Table 5. These product attributes have been used to derive the three well documented methods that address product characterization selection as shown in Table 5 below, which are: DWV^3 [37], the three-dimensional global classification system [38] and the Product Supply Characterization (PSC) model [7].

4.5   The DWV^3; The three-dimensional global classification system; & The PSC model product characterization selection methods

The DWV^3 classification system utilizes five of the product attributes defined in Table 5, namely the **D**uration of the product life cycle, the time **W**indow for delivery, the **V**olume, the **V**ariety and the **V**ariability, which build the acronym DWV^3. This classification method is mainly used to develop focused demand chains where processes are prioritised as a sequence of events with the end view of serving the ultimate consumer [38].

The three-dimensional global classification system utilizes three product characteristics from those listed in Table 5 namely: product, demand and lead-times [5]. Each characteristic is classified in one of two gradations [13]:

❖ Product (standard or special);
❖ Demand (stable or volatile); and
❖ Lead-time (short or long).

The three-dimensional global classification system focuses on linking the supply chain strategy with the product life-cycle management signifying that the most suitable supply chain strategy of a product differs depending on its stage in the product life cycle [13].

The Product Supply Characterization (PSC) model utilizes seven (7) product characteristics which are volume, volatility, order line value, frequency of order lines, order line weight, substitutability of a product and number of customers buying each product. The PSC's focus is on addressing total supply chain costs and service performance to the customer [5].

The DWV^3 and the PSC are perhaps the best suitable methods to be applied in a public healthcare pharmaceutical supply chain. This is largely because DWV^3 is employed in developing focused demand supply chain, which in this case the end goal will be to serve the patient. Furthermore, the PSC focuses on service performance to the customer, which in the case of the healthcare pharmaceutical supply chain would be the patients.

Sullivan et.al detailed the product attributes and the measurable characteristics as in Table 5 below, and the author interpreted the product attributes used in the DWV[3], the three-dimensional global classification system and the PSC, and provided the last three columns.

Table 5: Product attributes and their measurable characteristics (adapted and developed from [5].)

Product attributes	Examples of measurable characteristics	DWV[3]	The three-dimensional global classification system	PSC
Cost	Supply chain, inventory and manufacturing			
Demand	Variability, predictability, volatility and volume	✖	✖	✖
Quality	Defects and yield percentage			
Financial	Profit margin per part			
Product	Product characteristics		✖	✖
Life cycle	Phase and length of time in phase	✖		
Design	Manufacturability of the product			
Standardization	Few customized features of the product			
Customer	Responsiveness in service			✖
Uncertainty	Customer demand and market environment			
Delivery	On-time or on-schedule	✖		
Flexibility	Handling of change in demand, design and delivery			✖
Inventory	Product held in kanban/JIT inventory			
Lead time	Response time to deliver product		✖	
Production	Capability and capacity to produce in lean environment			

It can be seen in Table 5 that out of the 15 product attributes, demand and product have been the mostly used with demand being used by all three methods. This can be attributed to the fact that whether the focus point of product categorization is cost based, value based or needs based (as detailed in section 4.5), information about demand (variability, predictability, volatility and volume) seems essential. Moreover, product characteristics seem vital in the application of product categorization hence the product has been considered in two of the three methods in Table 5. It can be reasoned that depending on the focus point (as shown in section 4.5) of the South African public healthcare pharmaceutical supply chain, demand and product attributes will potentially be critical in the incorporation of product categorization too.

4.6 Which focus of the supply chain should product categorization target?

Dawe, Pittman and von Koeller [39] suggested that there are various focus points for supply chain product categorization and the methodologies employed depend upon the purpose. These include:

➢ **Cost-based.** Costs (and profits) cannot be disregarded in the development of the product categorization concept, however, cost-based analyses only (estimating, allocating and assigning costs) leave much unanswered particularly the shortcoming in tracking of costs directly to vital business entities [40]. The cost-based approach revolves around the connotation of resolving problems rather than seeking opportunities [39].

➢ **Value-based.** This categorizes products by economic value, for instance total revenue generated, which then disregards the cost-assigning-only approach to categories and actually segments them to determine profitability [13]. It is not categorizing just for the sake of categorizing therefore the categories should be sizeable enough to complement the supply chain strategy [36].

➢ **Needs-based.** Categorization is done on differentiated product drivers that clients have for a distinct supply chain service. Products are categorized based on a common set of clients' needs and internal resources, such as sales, and can provide insight on determining and validating the needs (met or unmet) [39]. The

purpose is to match sector needs with the correct supply chain service with the aim of gaining competitive advantage [4].

In the healthcare pharmaceutical supply chain, the product categorization concept would probably focus on the needs-based and cost-based requirements of the supply chain. This is primarily due to healthcare supply chains' focus on the availability of medication in a cost-effective manner.

5.   CONCLUSIONS, RECOMMENDATIONS AND FURTHER STUDY

Trends in research and current applications of product categorization dimensions have been analyzed using a systematic literature review. It is evident that a significant focus in research and application of the product categorization concept in the last ten years is shifting towards e-commerce probably owing to the growing widespread use of big data over the years. An acknowledgement of the concept of product categorization as applied in other industries as well as in healthcare supply chains has been established in this paper. The methods employed when applying product categorization as well as focus of the supply chain which it should target is established too. Furthermore, the concepts of supply chain management and generic supply chain models are discussed. This all laid a research agenda platform for determining the viability and value of incorporation of product categorization in the South African public healthcare pharmaceutical supply chain.

It is therefore recommended that, in harmony with the implementation of VAN, where it is stated [5] that the first three years of implementation will focus only on 'getting the pharmaceuticals to the point of need', the next focus after three years being 'selecting the right pharmaceuticals', research should thus be conducted on categorizing the pharmaceuticals according to their demand aspects and product attributes so as to optimize the selection and handling of the right pharmaceuticals in the healthcare pharmaceutical supply chain. This can be facilitated by the effective incorporation of product categorization in VAN in order to match the right product attributes with the right supply chain strategy and develop the right supply chain practices and policies. This will most probably optimize the performance of the South African healthcare supply chain and ensure sustainable medicine availability in a cost-effective manner, with probable benefits in scoring factors like on-time performance, supply flexibility, delivery frequency, minimum lot sizes, supply quality, inbound and outbound transportation cost, information coordination capability and design collaboration capability etc. A further study should be undertaken on how to incorporate product categorization in VAN (and NDOH) for demand planning; supply planning; and distribution planning, matching product categories with the right supply chain strategies and enhance the supply chain performance.

6.   REFERENCES

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