IDENTIFICATION OF HEALTHCARE SUPPLY CHAIN PRACTICES USING THE FUZZY-DELPHI APPROACH

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Abstract

In Nigeria, the healthcare supply chain system has been described as fragmented, uncoordinated, and inflexible in meeting patient ever-changing demands. Thus, the need to effectively and resourcefully manage health care supplies cannot be overemphasized as it depicts a drastic influence on the efficiency of the health system, as medications fail to meet the right end-user at the right time, right cost, right quality, and the right place. Therefore, to meet customer demands, the implementation of supply chain practices is of paramount need. In view of this, the study is focused on assessing the experts' communal opinion on significant supply chain practices needed in enhancing the overall efficiency of the healthcare supply chain system of the Lagos University of Teaching University (LUTH) with the aid of the fuzzy Delphi approach. Using a cross-sectional survey approach, three out of five supply chain experts' opinions were analyzed and it was found that ten (10) out of twenty assessed supply chain practices are relevant to the healthcare supply chain system of the Lagos University Teaching Hospital (LUTH). However, to achieve timely efficiency in the healthcare supply chain, the most important practices are the reduction of redundancy and unnecessary materials, the usage of information technology in integrating activities within the healthcare, prequalification of suppliers, and rapid response to special demands with respect to their defuzzy value without negating the spontaneous effects of demand visibility, flexible sourcing, and value stream analysis.

Keywords: Supply chain practices, Healthcare supply chain, Fuzzy-Delphi Approach

1. Introduction

In Nigeria, the availability of healthcare facilities has grown to all the local governments basically on the platform of primary healthcare centres. Moreover, the nation has continually developed its presence in healthcare with the availability of secondary healthcare facilities (general hospitals), tertiary healthcare centres (federal medical centres and teaching hospitals), and specialties hospitals (Medic West Africa, 2019). However, in spite of their availability, quality healthcare service delivery has been continually shortened in most states with respect to the low doctor-to-patient ratio (Medic West Africa, 2019), poor access to essential medicines, and stockouts of medications (Oyekale, 2014), inflexibility of the supply chain in meeting patients' varying

demands and medical needs and high supply chain cost (Dowling, 2011; Nsikan, Ekiens, Tarela, & Affiah, 2018), insurgency and last-mile supply chain disruption (Ottih, Cussen, & Mustafa, 2018; Aigbavboa & Mbohwa, 2020), among other supply chain issues. Thus, as medications fail to meet the right end-users at the right time, right cost, right quantity, and at the right place, the need to proffer strategic solutions to supply chain issues surrounding the availability, accessibility, and affordability of essential medications at all looks and corners of the nation has become a necessity to stakeholders and respective agencies within the healthcare industry (Nsikan, Okon, & Uduak, 2019). Additionally, the need for continuous improvement of healthcare supply chain performance thereby making the supply chain more streamlined, flexible, efficient, and sustainable in meeting the UN 2030 Sustainable Development Goals (SDGs) of good health and well-being for all is also of great importance. Therefore, in the bid of meeting customer demands, performance-enhancing supply chain practices that are relevant to the study area are of paramount need (Dahlgaard, Pettersen, & Dahlgaard-Park, 2011). This is because; the usefulness of selected supply chain practices could differ from industry to industry. Moreover, promoting reduced service cost and lead time variability, improved service level and satisfied patients, and better workflow for hospital employees entails the implementation of contributory and efficient supply chain management practices (Nsikan *et al.,* 2018). In view of this, this study is focused on assessing experts' communal opinions on supply chain practices as they influence the overall efficiency of the healthcare supply chain system with the aid of fuzzy Delphi approach. Thus, the research question is as follows:

i. which of the supply chain practices are relevant to the continuous improvement of the healthcare supply chain system of the Lagos University Teaching Hospital (LUTH)?

2. Review of Literature

2.1 Theoretical Framework

This study employed the resource-based view theory as the lens through which the significance of supply chain practices is observed within the healthcare supply chain system.

2.1.1 Resource Based View Theory

The theory resource-based view was propounded by Barney in 1991 as a managerial philosophy geared towards maximized utilization of firms' ingrained resources and capabilities to actualizing stated organizational objectives. The theory is backed on how firms through their acquired and controlled resources and capabilities actualize sustainable competitive advantages. According to Grant (1991), the theory describes, predicts, and explains how organisations (manufacturing or service) utilize their resources (tangible or intangible) that are characterized as valuable, rare, inimitable, and non-substitutable in a bid to achieve sustainable competitive advantage and

organizational performance. Therefore, as supply chain competes against each other (Azevedo *et al*, 2011), it does that based on the ingrained unique strategic capabilities that are heterogeneous in nature to respective supply chains and depicts their magnitude and differences in performance (Barney, 1991). To this effect, lean, agile, resilient, and green (LARG) supply chain practices are considered strategic capabilities unique to supply chain that possesses them as they fulfill the resource-based theory attributes of valuable, rareness, imperfectly imitable, non-substitutable, and can be exploited by an organization. In addition, these practices are deliberated to be intangible strategic capabilities that make them more demanding to be replicated, however, exploited to aid continuous improvement of supply chain performance within an ever-changing and turbulent business environment.

2.2 Review of Concepts

2.2.1 Healthcare Supply Chain

The healthcare supply chain involves the flow of pharmaceutical materials, medications, vaccines, drugs, and medical information within healthcare supply chain stakeholders in the most efficient manner. It is a complex network of agents involved in varying upstream and downstream activities and processes within the supply chain system to ensure the free flow of value-added products to consumers at the right timing and cost to save and improve lives (Rakovska & Stratieva, 2017). Thus, the healthcare supply chain is as important as the satisfaction of customers' demands (Azevedo, Carvalho, & Cruz-Machado, 2011; Rakovska & Stratieva, 2017). It is an embodiment of a large range of specialized products (such as pharmaceutical supplies and medical devices, among others) influenced by physicians' preferences. Operationally, the healthcare supply chain costs a hospital and its stakeholders 40% of its operating budget. Hence, to aid continuous improvement in healthcare operations, an industry of this nature could benefit largely from the operational, economical, and sustainable efficiencies of supply chain management (SCM) principles (Cabral, Grilo, & Cruz-Machado, 2012; Dahlgaard *et al.,* 2011).

2.2.2 Supply Chain Practices

Supply chain practices are a set of activities implored along the supply chain value system to enhance supply chain performance. Hence, healthcare supply chain practices are activities implemented along the healthcare supply chain system to aid effective management of the supply chain and its stakeholders towards supply chain performance and organisational performance (Mathur, Gupta, Meena, & Dangayach, 2018). To this end, several metrics have been utilized in assessing supply chain practices. Adebanjo, Laosirihongthongb, and Samaranayake (2016), assessed supply chain practices using lean supply chain management practices of total productive maintenance, work standardization, automated system, vendor managed inventory, electronic medical record, vehicle route planning, and quality certification. Likewise, Mathur *et al*., (2018) examined hospital supply chain practices and supply chain performance using

total management commitment, inventory visibility, lean practices, and supplier integration as proxy for healthcare supply chain practices. Whereas, Nsikan *et al.,* (2019) assessed supply chain practices using strategic supplier partnership, information/knowledge sharing, supplier selection decision, collaborative inventory planning and forecasting, and information technology integration. However, in making supply chain operations more streamlined, flexible, efficient, and sustainable simultaneously, integrating SCM paradigms have become inevitable (Al-Refaie, Al-Tahat, & Lepkova, 2020). In improving the diary supply chain in Iran, Akbarzadeh, Ghadikolaei, Madhoushi, & Aghahani, (2019) reported the best combination of supply chain practices within the industries through the integration of lean, agile, resilient and green supply chain practices. Likewise, Abd-Rasidi, Mohd Salleh, & Jeevan, (2019) conducted a compatibility analysis of supply chain practices in enhancing seaport supply chain practices through the integration of lean, agile, resilient ang green supply chain paradigm. Moreover, to enhance the supply chain performance with the manufacturing industry, Azevedo *et al.,* (2011) examined supply chain practices from the standpoints of lean, agile, resilient and green paradigm. While, Cabral *et al.,* (2012) assessed the relative influence of supply chain practices on supply chain competitiveness and efficiency of the automotive industry using an integration of lean, agile, resilient and green paradigm. In view of this, this study operationalized supply chain practices using a simultaneously integration of lean, agile, resilient and green practices. Lean practices can be described as activities that encourages doing more with less and lesser resources (Womack, Jones, & Ross, 1990). Thus, it is aimed at waste reduction and mitigation of non-valuable processes within the supply chain system, and actualization of customers' demands at the lowest possible cost (Matt, Arcidiacono, & Rauch, 2018). While, agile supply chain paradigm entails activities that promotes flexibility and dynamic capability of the supply chain system. That is, practices that enables the healthcare supply chain system in responding rapidly to uncertainty and changes in patient demands while maintaining market sustainability (Akbarzadeh *et al.,* 2019; Cabral *et al.,* 2012). Resilient practices are an embodiment of management principles and practices ingrained within the supply chain system in aiding quick and efficient responses to healthcare supply chain disruptions (Abd Rasidi *et al.,* 2019; Al-Refaie *et al.,* 2020). Thus, it deals with the capability of a supply chain system to return to its initial state or move to an improved state either through mitigation or contingency strategies after experiencing systemic disruption (Christopher & Peck, 2004; Tomlin 2006). According to Srivastava (2007), green supply chain practices are aimed at managing the environmental sustainability of the supply chain through the integration of environmentalist approaches along the supply chain. Thus, the green paradigm is an organisational philosophy aimed that actualizing stated corporate and market objectives and profit through the reduction of environmental risks.

2.2.3 Fuzzy Delphi Approach

Fuzzy Delphi method is an improved version of the traditional Delphi method for enhancing ambiguity in decision-making. It is a structured communication approach that comprised of fuzzy set theory and Delphi method in assessing experts' linguistic preferences while making decisions (Bouzon, Govindan, Rodriguez, & Campos, 2016; Chen, Wang, Wang, & Shen, 2018). In view of this, literature has portrait the significance of fuzzy Delphi method in strategic decision-making areas such as, reverse logistics (Bouzon *et al.,* 2016), road safety performance (Ma, Shao, Ma, & Ye, 2011), alignment of communities of practices (Jassbi *et al.,* 2015), campus sustainability (Chen *et al.,* 2018), among others.

3. Methods

The study adopts a quantitative and analytical research approach which is in support of the positivism theoretical ground. In addition, a cross-sectional survey with the aid of fuzzy Delphi structured questionnaires was used for addressing the research question. This is because fuzzy Delphi helps in identifying and prioritizing variables as it affects a study area with little or no room for experts' bias and subjectivity (Bouzon *et al.,* 2016; Jassbi *et al.,* 2015).

3.1 Population

The study's population comprised of all supply chain practitioners involved in the procurement, administration, storage, and distribution of medical supplies and equipment within the Lagos University Teaching Hospital (LUTH) at the time of this study totaling 47 as contained in the database of the hospital's human resource management Department.

3.2 Sampling Procedure

In a bid to achieve the stated objective of the study, the sample size of the study was limited to 5 experts from the unit of analysis, with respect to their far-reaching knowledge and a wealth of experience in supply chain operations, procurement, and practices were selected based on the convenience sampling technique and the guidance of the Head of the Store Department.

3.3 Data Collection

Since this study is aimed at identifying supply chain practices applicable to the public healthcare sector, the measuring variables lean, agile, resilient, and green practices was measured in line with existing literature to facilitate their assessment. Hence, to collect necessary data, 5 items each for lean, agile, resilient, and green practices were adapted from Azevedo *et al.,* (2011), Carvalho, Duarte, & Cruz-Machado, (2011), Cabral *et al.,* (2012), Abd Rasidi *et al.,* (2019), Akbarzadeh *et al.,* (2019), Borges, Tortorella, Rossini, & Portioli-Staudacher, (2019), Farias, Santos, Gohr, & Rocha, (2019), and Al-Refaie *et al.,* (2020).

To aid the collection of data, the study was conducted using structured questionnaires in accordance with the proposed research design. The structured fuzzy Delphi questionnaire which was administered to 5 experts was designed in close-ended questions format with responses based on a ranging scale from 0 – 6 (indicating "absolutely insignificant (0)", to "absolutely significant (6)") with the attributed linguistic variable as described in Table 1 using fuzzy triangular numbers for evaluation purposes. This helps in ascertaining the significance of measuring LARG variables within the healthcare supply chain industry. Hence, the experts' group decision was actualized using the geometric mean method, and the decision rule for the selection of variables will be based on surpassing a benchmark value derived from the geometric mean computation (Bouzon *et al.,* 2016; Ma *et al.,* 2011).

Table 1: Fuzzy Delphi Triangular Number

Linguistic Variables	Triangular Number (a_{ij} b_{ij} c_{ij})
Absolutely Inappropriate	(0, 0, 0.1)
Inappropriate	(0, 0.1, 0.3)
Fairly Inappropriate	(0.1, 0.3, 0.5)
Indifferent	(0.3, 0.5, 0.7)
Fairly Appropriate	(0.5, 0.7, 0.9)
Appropriate	(0.7, 0.9, 1.0)
Absolutely Appropriate	(0.9, 1.0,1.0)

Source: Adapted from Bouzon *et al.,* 2016.

3.4 Data Analysis

In a bid to achieve the aim of the study, the analysis of collected data with the aid of Excel Solver (Microsoft Excel) was actualized following the procedure of fuzzy Delphi as stated:

Step 1: Identify supply chain practices as related to the study: The evaluation criteria are obtained through a literature survey, experts' knowledge and experience, and other appropriate methods.

Step 2: Collection of expert opinions on the evaluation criteria: According to Akbarzadeh *et al*., (2019), the relative importance degree of the criteria are derived based on a standard scale of 0 – 6 (indicating "absolutely insignificant (0)" to "absolutely significant (6)"). Thus, decision-makers were asked to identify the level of significance of the supply chain practices as related to the healthcare supply chain system within the unit of analysis. Henceforth, the experts' group decision was actualized based on the computation of the geometric mean of the decisions.

Step 3: Prioritization of evaluating variables: Since the values are in fuzzy form, they were firstly defuzzify (that is, converted to crisp values) based on the center of gravity approach (see formula 1). Afterward, the prioritization of

variables was actualized via the comparison of the group decision value on criteria to the computed benchmark (threshold) value "*T*" actualized from the geometric mean of all supply chain practices weight value. Thus, the decision rule is as stated:

If $X_j \geq T$, select supply chain practice j

If $X_j < T$, reject supply chain practice j

$$X_j = \frac{a_j + 4b_j + c_j}{6} \quad (1)$$

Where a_j is the minimum value of variable *j*, b_j is the geometric mean of variable *j*, and c_j is the maximum value of variable *j*; *j* = 1, 2, 3, …, n.

4. Results

A total of 5 questionnaires were administered to supply chain practitioners with far-reaching knowledge and a wealth of experience in supply chain operations, procurement, and practices, storage and distribution of medical supplies and equipment within the Lagos University Teaching Hospital (LUTH), Lagos State, Nigeria (see Table 2). Of these, 4 were returned, representing an 80 percent response rate. Out of the questionnaires returned, 3 representing 60 percent of the total questionnaire administered, were properly completed and found valid for the analysis of this study.

Table 2: Expert Profile

	Designation	Qualification	Industrial Experience (years)	Professional Qualification
Expert 1	Deputy Director of Procurement	Masters	21 and Above	Chartered Institute of Purchasing and Supply Management
Expert 2	Assistant Chief Store Officer	Degree	21 and Above	Chartered Institute of Purchasing and Supply Management
Expert 3	Store Officer	Degree	21 and above	Chartered Institute of Purchasing and Supply Management

Following the analytical procedure of fuzzy Delphi methodology, the study results are discussed.

Step 1: Identify supply chain practices as related to the study: In view of this, the evaluation model contains 4 supply chain paradigms namely; lean, agile, resilient, and green. The lean paradigm comprised of just-in-time (L1), value stream mapping (L2), standardized work (L3), an automated system (L4), and pull system (L5); the agile paradigms were proxied by rapid response to special demands (A1), use of information technology in integrating activities within the hospital (A2), excess buffer capacity (A3), dynamic alliance (A4), and

centralized and collaborative planning (A5) while, the resilient paradigm were measured by strategic stock (R1), demand visibility (R2), flexible sourcing (R3), risk sharing (R4), and responsiveness in resilience (R5). Whereas, the green paradigm comprised of reuse of materials and packages (G1), prequalification of suppliers (R2), environmental emission control (R3), reduce redundant and unnecessary materials (R4), and waste recycling (R5).

Step 2: Collection of expert opinions on the evaluation criteria: Using a standard comparison scale of 0 – 6 indicating "absolutely insignificant (0)" to "absolutely significant (6)" for data collection, the unified group opinion was derived via geometric mean (see Table 3) for identifying domesticated healthcare supply chain practices.

Step 3: Prioritization of evaluating variables: On the basis of the decision rule is as stated in the methodology, those variables whose values are greater or equal to the threshold value "*T*" (0.4903) are accepted while others rejected (see Table 3).

Table 3: Fuzzy Delphi Results of Healthcare Supply Chain Practices

Paradigm	Practices	Min	Geometric Mean	Max	Defuzzy	Decision
Lean	L1	0.1	0.3557	0.9	0.4519	Reject
	L2	0.5	0.5000	0.5	0.5	Accept
	L3	0.0	0.0000	1.0	0.3333	Reject
	L4	0.1	0.2924	0.5	0.2975	Reject
	L5	0.1	0.2924	0.5	0.2975	Reject
Agile	A1	0.5	0.6270	1.0	0.709	Accept
	A2	0.5	0.7948	1.0	0.7349	Accept
	A3	0.3	0.5130	0.9	0.571	Accept
	A4	0.0	0.0	0.5	0.1667	Reject
	A5	0.0	0.0	1.0	0.3333	Reject
Resilient	R1	0.1	0.3557	0.9	0.4519	Reject
	R2	0.5	0.6804	0.9	0.6935	Accept
	R3	0.5	0.6804	0.9	0.6935	Accept
	R4	0.5	0.6804	0.9	0.6935	Accept
	R5	0.1	0.3684	1.0	0.4895	Reject
Green	G1	0.0	0.0	0.5	0.1667	Reject
	G2	0.5	0.7399	0.9	0.7133	Accept
	G3	0.5	0.5594	0.7	0.5865	Accept
	G4	0.5	0.7663	1.0	0.7554	Accept
	G5	0.0	0.0	0.5	0.1667	Reject
Threshold	T	0.265	0.4058	0.8	0.4903	

Source: Authors' computation, 2022.

5. Discussion

The results of the analysis revealed that ten (10) out of twenty assessed supply chain practices are relevant to the healthcare supply chain system of the Lagos University Teaching Hospital (LUTH). Thus, within the lean category of supply chain practices, value stream analysis was the only practice considered relevant. This is in collaboration with the position of Sharma, Dixit, Dixit, and Qadir, (2016) on the importance of value stream mapping in the reduction of waste. Among the agile practices, three out of five practices were considered relevant namely; rapid response to special demands, use of information technology in integrating activities within the hospital, and excess buffer capacity. This supports Cabral *et al.,* (2012) and Akbarzadeh *et al.,* (2019) findings on the importance of agile practice of rapid response to special demands and usage of information technology within the automotive industry in Portugal and the Iranian dairy industry respectively. Likewise, within the measured resilient variables, three out of five practices were ascribed relevant by experts' communal opinion. While, the following practices; prequalification of suppliers, environmental emission control, and reducing redundancy and unnecessary materials were those considered significant under the green supply chain practices. In support to this, Akbarzadeh *et al.,* (2019) reported the importance of prequalification of suppliers within the supply chain system of the dairy industry. Altogether, to achieve efficiency in the healthcare supply chain, the following intangible strategic capabilities; reduction of redundancy and unnecessary materials, the usage of information technology in integrating activities within the healthcare, prequalification of suppliers, and rapid response to special demands are of paramount importance with respect to their defuzzy value.

6. Conclusion

The need to enhance the performance of the healthcare supply chain cannot be overemphasized however; this can only be done through proper knowledge of relevant practices for its continuous improvement. In view of this, the following conclusions are made:

i. Managerially, the study has shown that to proffer continuous improvement solutions to the complex healthcare supply value chain system in LUTH, every element of waste related to redundancy and unnecessary materials within the supply chain process need to be strategically reduced in order to aid good healthcare and wellbeing for all.
ii. Moreover, the usage of information technology in integrating activities within the institution, prequalification of suppliers, and rapid response to special demands are supply chain practices that should be highly prioritized alongside demand visibility, flexible sourcing, and risk sharing in enhancing supply chain performance.

7. Limitations and Suggestion for Further Studies

Basically, the study was conducted in one of the university teaching hospitals (a subunit of the tertiary healthcare system in the country) however, considering the cultural complexity of Nigeria; the findings at the unit of analysis which is within a sub culture might not be effective when presented with other sub culture. Thus, this restricts its generalization. Therefore, an extension of such study to include other tertiary healthcare system is advised. Moreover, the primary and secondary public healthcare system, and private sector of the country's healthcare system can be observed. Likewise, the supply chain practices observed can be increased upon to broaden the quality of decision available to policy makers.

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