Enhancement of Supply Chain Performance by Data Analytics

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Abstract

Supply chain management is not only crucial for manufacturing industries but also for service industries. It deals with managing the process of having the right item in the right quantity at the right time at the right place for the right price in the proper condition to the right customer, and the importance of collaboration of supply chain management with data management is undeniable in the health care management system. This research aims for an integrated and collaborative approach between healthcare supply chain stakeholders that optimizes the supply chain in providing high-quality service at a relatively lower cost with more accurate forecasting, exploring trends in different calendar parts to effective decision-making. It also focuses on managing Electronic Medical Records (EMRs) efficiently through inventory monitoring using Data Management and Data Analytics tools, improving safety, and enhanced Quality Assurance. As the health care supply chain systems differ based on the country and their health care management system facilities, this study was only concentrated on the health care supply chain of Bangladesh.

Keywords

Health Care Supply Chain, Data Analytics, Supply Chain Performance, Data Management, Electronic Medical Records.

1. Introduction

The healthcare system accounts for providing high-quality healthcare services at affordable expenditures being a fundamental right for the citizens of a nation. The healthcare system is confronting rising challenges of providing the services at lower costs due to striving from operational inefficiencies of which expense, about 45% comes from the supply chain itself that comprises suppliers, drugs, and consumables (Alotaibi & Mehmood, 2018). Organizations have to look for an approach that optimizes their supply chains through more accurate visualization and predictability of any demand surge or factors that affect materials planning through proper management of Electronic Medical Records(EMRs). A Digital Transformation of the Supply Chain of the healthcare sector can address the issues prevailing in the business process of a healthcare service sector that impedes efficient management that pertains unavailability of medication to patients in proper time impacts the overall quality of care received by a patient.

The healthcare supply chain involves multiple stakeholders that generate a massive volume of Electronic Medical Records(EMRs) stored by healthcare organizations opening a new horizon of improving services by extracting information analyzing data in the current era of advanced technologies. Such data analysis measures and data management can facilitate inventory monitoring seeking solutions for existing issues, and eradicating fraud, abuse, waste, and errors (Alotaibi & Mehmood, 2018). Thus, Integration developed through Digital Supply Networks enhancing connectivity among stakeholders can promote the inventory replenishment cycle's visibility, which allows better surveillance of a firm's operations.

In this paper, our main aim is to propose a refurbish approach of developing digital healthcare supply chain network connectivity that coagulation of stakeholders on a common platform that enhances the visibility, predictability and appropriate decision making aiding in the increase of efficiency, therefore, enhancement of the overall performance of the healthcare supply chain.

2. Background
This section depicts the work by describing the fundamental terminologies that are involved in this paper. The key terms, for instance, Supply Chain, Inventory Monitoring, Data Analytics, digital Footprint are illustrated based on reviewed references.

2.1. Supply Chain
Supply Chain comprises the arena from raw materials' procurement to all the processing required and the final delivery of goods. Supply chains instruct when the product should be made, delivered to storage and centers, and finally delivered to a retail store or shipped (Sharma, 2020). Malik et al. define supply chain as "the process of having the right item of the right quantity at the right time at the right place in the right place for the right price in the right condition to the right customer"(Malik et al., 2018). With this definition, the importance of the efficient running of the supply chain can be realized in making a business successful. All such activities directly or indirectly involve fulfilling a customer request. There has been significant Digital Transformation in the supply chain scenario throughout the world and supply chain managers have played a crucial role in integrating supply chains to the current digital ecosystem. Through the evolution of supply chain, the concepts of Data Analytics, usage of Digital Footprint integrated with Internet comes into play that leverage in creating competitive advantage incorporating Digital Supply Chain contributing to empowerment of responsible value chains. Such adoption of new technologies can leverage in making supply chain decisions that determine to a large extent the success of sectors, companies, and nations.

2.2. Data Analytics in Digital Supply Chain
The business impact of Supply Chain decisions is undeniable in terms of ensuring high performance with a renewed focus on strategies (World Economic Forum, 2015). There are no better means than adopting Digitization through Supply Chain integration to pursue such company goals of achieving commercial and socio-economic advantage. Hence, merging of supply chain stakeholders through digitization-from the sourcing of raw material to manufacturing and logistics and finally to customer order fulfillment into an end-to-end digital ecosystem yields better data visualization. Moreover, data analysis obtained through such digital integration can drive efficiencies, boost innovation, and reduce risk increasing supply chain resiliency and responsiveness and unprecedented flexibility and visibility (Henson, 2020). Data generated through supply chain integration from different stakeholders can better anticipate customer order placement by usage of predictive analytics tools, foresee the availability of raw material, and prepare for combating any unusual disruptions with increased resiliency. Efforts of digital supply chain incorporation and promulgation throughout the entire value chain can pave the foundation for a well-architected supply chain model anchored with four key pillars - namely predictability, agility, traceability, and sustainability and the firms that get this right will be well-positioned for lasting competitive advantage and a market-leadership role in the future (Hackenberg, 2018).

2.3. Digital Footprint
A digital footprint is an impression created on the internet based upon a person's online activity or an organization that includes the trail of data left behind from internet surfing, which can be intentional or unintentional (Reyes, 2020). Digital footprint can be a representation of a business whose accuracy can yield in leveraging accomplishment of business goals, at the same time, enhancing a firm's reputation. Having a positive digital footprint can lead to the benefits of increased opportunity, reduced risk, and higher profits (Reyes, 2020). In the current era of a digitized world, supply chain integration on digital platforms can lead toward having informatics and accumulative data of supply chain drivers whose analytics can enhance predictability and further exploration of data to ensure the sustainability of the business. The application of utilization of data generated from digital footprint is not just limited inbound an organization rather in multifarious sectors having distinctive contributions in respective areas.

2.4. Digital Footprint in the Healthcare Supply Chain
The Healthcare Supply Chain includes multiple stakeholders and eventually has been one of the most complex supply chains to manage. Lack of appropriate application of modern technological advancements has been a key behind discrepancies and inefficient management that ultimately affects the quality of service. The usage of Digital Footprint

can work as the antidote for healthcare supply chain inefficiencies through integration and interconnection of stakeholders upon compliance on a centralized data hub which will generate a digital footprint of patient behavioral pattern and trend analysis and help increase resiliency and sustainability combating unanticipated risk management (Roytberg, 2018). Digital footprint in the healthcare supply chain might include the data on inventory replenishment of a hospital, its order placement, and delivery receiving cycle from the point of view of both hospitals, wholesaler and retailer. Data thus generated can be capitalized in becoming a more adaptive healthcare enterprise through effective data management and data analytics, which is crucial for staying resilient (*Digital Footprint Data Management*, 2020). Medical service provider agencies, on the other hand, can create their own data hubs of digital Electronic Medical Records(EMRs) integrated mutually with other hospitals on a centralized platform with access of supply chain stakeholders upon compliance that can help accelerate treatment response times and create positive impact on the quality of patient service as a whole (Harjumaa et al., 2016; Roytberg, 2018).

2.5. Inventory Monitoring in Healthcare Supply Chain

Inventory management in the healthcare supply chain has been one of the most challenging areas to deal with as it involves replenishment, storage and delivery of perishable, sensitive and typically expensive medical products. It is a dire necessity to hold sufficient amounts of inventory whose shortage can hinder in providing healthcare services that can even risk the life of a patient as a survey of 2015 done by Cardinal Health found 18% of respondents had heard of a patient being harmed due to lack of supplies (Lange, 2020). Having greater visibility of inventory data can offer the healthcare supply chain to act proactively with more accurate forecasting and means to reduce cost throughout the entire healthcare value chain. It is possible to drive an effective and efficient inventory management contributing to the overall supply chain cost reduction through implementation of integrated inventory monitoring. This paper intends for proposing implementation of such an integrated inventory monitoring having the access and visibility of stakeholders through inventory information sharing that can help manage inventory efficiently and keep up the satisfactory service level (Leaven et al., 2017). Having the facility of continuous monitoring of inventory data can aid in identifying potential inventory issues and accordingly early response mitigating evolving threads.

2.6. Inventory Database Management System and Data Analytics

Having a centralized database integrating healthcare supply chain stakeholders can take the efficiency to the next level along with increased resilience and risk mitigation through improved data visualization (LaPointe, 2020). Inventory databases might include data of expected number of daily refills, the storage space utilization and the service level of the stakeholders that can provide insights on ways to optimize inventory and purchasing (Leaven et al., 2017). Data is considered as the golden nugget in making proactive informed decisions by experts at Cardinal Health whose analytics can offer innovative healthcare systems more visibility into supply chain management issues, allowing for reduced costs and greater efficiencies (Damron, 2015; Lange, 2020). Here comes the importance of digital footprint data utilization from healthcare supply chain inventory databases whose management can monitor and provide information on ramping up of safety stocks for any unprecedented emergency situation through real time visualization of critical item inventory position that enables quick mitigation and stakeholder awareness. Hence, database management of digital footprint data of stakeholders' inventory can assess stock-on-hand, demand and desired quantity through collaboration within hospital and supplier base that can drive quick assessment of inventory gaps and trends and improve overall healthcare supply chain resiliency.

3. Research Methodology

3.1. Study of Supply Chain Process in Health Care

The interviews and the system mapping that we did the diagram represent the inventory management and the ordering process between any wholesaler and the public clinic. In the system, the public clinic holds the responsibility of managing the inventory, determining the demand and finally ordering to the wholesaler. Furthermore, the wholesaler's responsibility starts from having the order and it ends at the delivery being made. But the more important thing is determining the right demand at the right time along with calculating the trends and analyzing the inventory. And in Bangladesh the public clinics don't use any data upon which they could determine and predict the demand and take reasonable actions. Instead they use their experience and manually predicted demand to order and this whole process cause them more lead time and more inventory space for safety stock. And for this trivial approach the healthcare industry is much less efficient in terms of time and inventory management. But in health care supply chain system the stockless approach and just in time (JIT) approach is also extremely risky and both should be avoided because the cost of system failure can risk someone's life. An illustration of current health care supply chain is presented in Figure 1.
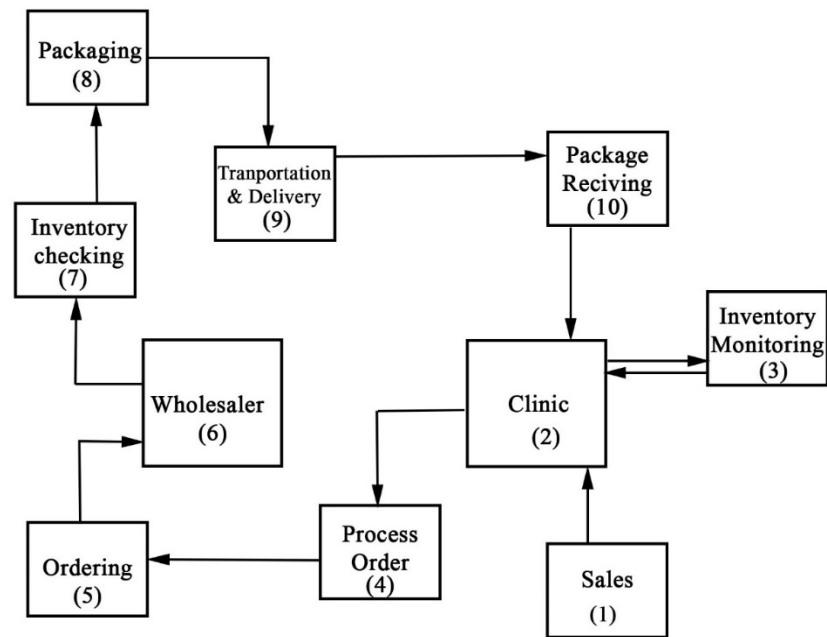
Figure 1: An illustration of the current health care supply chain

3.2. Problem Identification

Depending on the clinics and the health care companies' information, we came to recognize some issues with the current system. These problems are identified through the findings from process mapping, interviews and using the data collection techniques.

3.2.1. Emergency Orders

As explained earlier the clinics do not predict the demand based on any data-driven system, rather they just use experience to figure out the demand, which often results in a shortage in inventory or shortage in the safety stock. And in public clinics with regular orders, there is generally four to five days of lead time, which is another reason that increases the risk of a stock out. That's why emergency orders need to be delivered within a short time. And the scattered location of clinics from the location of wholesaler's inventory is another reason which increases the transportation cost and lead time. Inventory Cycle is illustrated in Figire 2.

3.2.2. Wholesaler's Stock Availability

Usually the inventory replenishment is done at the wholesaler's inventory based on the orders of the clinics. And that is why it's really difficult for the wholesaler to figure out the clinics requirements and forecast their demands. And because the order is placed mostly twice a month that is why there is a good chance of dealing with stock out problems. And due to the fact, that is no trend tracing done by the wholesaler that is why they will find difficulty if same products are ordered by few clinics at the same time. Some clinics will not get their order delivered until the new stock arrives.
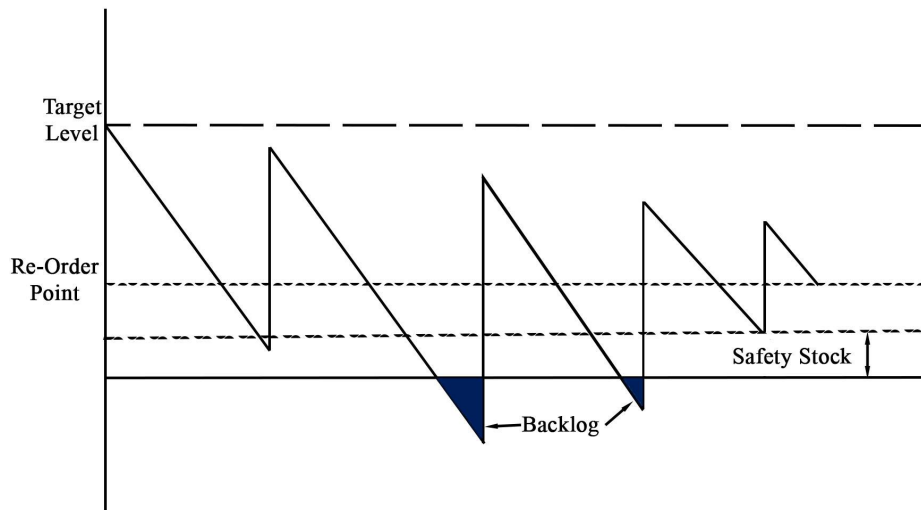
Figure 2: Inventory Cycle

3.3. Suggested Strategy

Because risk of JIT and stockless approach is really high and the cost can be the risk of someone's life that's why we have to reduce the risk. And to do so we have to assure optimal distance of the wholesaler's inventory from the clinics. This will reduce the transportation cost and will also improve the service level. Because we already know that the current transportation network system is not efficient that's why VMI based solution represents the best alternative.

3.3.1. Vendor Managed Inventory

In recent days, Vendor Managed Inventory has been an approach for minimizing inventory costs whose adoption aids in reduced inventory levels for having the advantage of determining the timing and quantity of replenishment having the access to retailer's inventory and demand data (Darwish & Odah, 2010).The proposed inventory management strategy of this paper goes in line with such VMI approach where the vendor can foresee the order placement and replenishment cycle from demand trend analysis of digital footprint database. The digital platform of database management based on collaborative network among stakeholders allows seamless aggregation of data from retailer, hospital, suppliers and systems provides insights to vendor on holding adequate level of inventory ensuring end-to-end instrumentation of a continuous process. The advantage from a vendor's viewpoint is reduction of operating cost and increase of profitability. On the other hand, benefits from a client's viewpoint is safeguard product availability and reduction of cost of inventory and administrative costs using this process (*Vendor Managed Inventory - Welcome*, n.d.). In addition, retailer incurs no ordering cost and guarded against excessive inventory by contractual agreement (Darwish & Odah, 2010). Hence, application of database management based on digital footprint data on inventory replenishment cycle, visualization of demand generation trend via data analytics can contribute in effective management of inventory as the vendor is entitled with the responsibility of stock control in VMI.

3.3.2 Implementation

The problem which has been occurring in the healthcare supply chain system, has already been discussed in the previous section in this paper. Now we'll discuss about the possible solution of that particular problem. A flow chart has been given below.
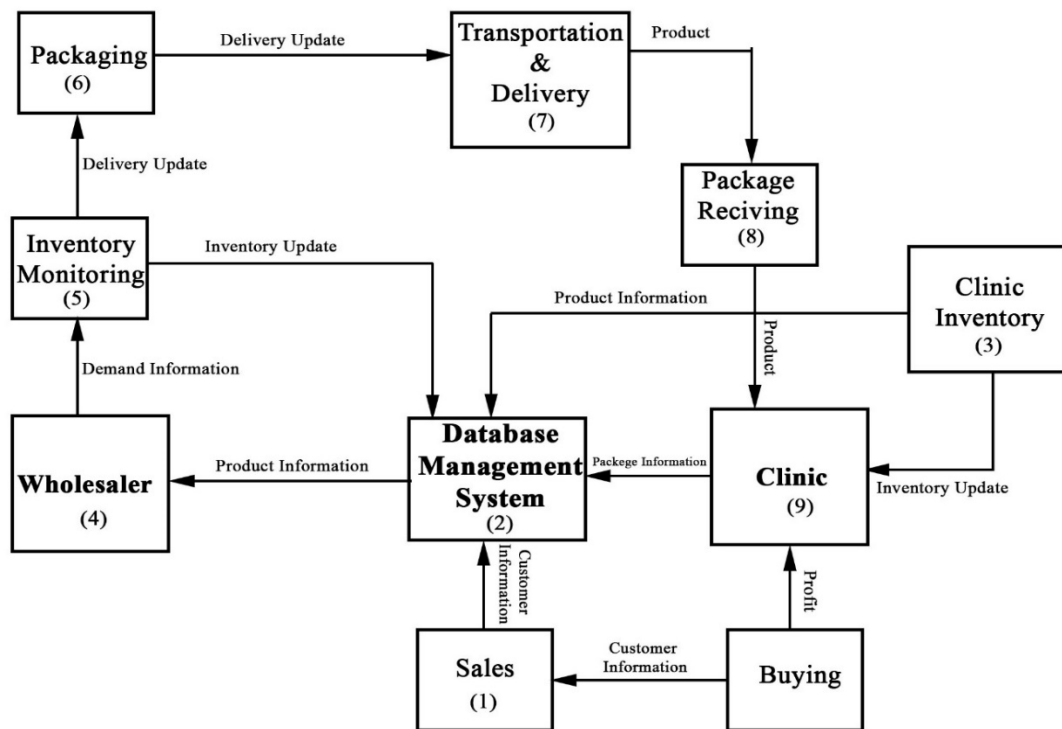
Figure 3: New Layout of the Health Care Supply Chain

The main problem is the communication gap between the wholesaler and the clinic authority. Now we're proposing a new system where the main actor will be the wholesaler. There will be a central database system, which will be monitored by both the wholesaler and the clinic authority as well.

Looking at the flow chart depicted in Figure 3 very carefully, anyone can understand the full procedure.

It will start with the very first sales dept. of the hospital. Because they are the first who contain the selling information about the patient/customers. Now when they are confirming the customer details, after completing this task, they will send/update the information of the customers and the demand as well to the central database system. In other word, they will provide the information to that system. Now the wholesaler will be able to identify the actual demand at actual time. They will have the access of that particular database system. After finding out the demand from the database, the wholesaler will check his inventory whether the demanded product is in there or not. If there is available units of the demanded product then the wholesaler will confirm the order and start packaging for delivery simultaneously. And after packaging, the wholesaler will send the package to the hospital and update the database system about that particular product. The hospital will receive that package and they will send that to their own inventory. But in this case the update of hospital inventory will be done by both the authority of that hospital and the wholesaler.

3.3.3. Inventory Database Management System and Data Analytics

Having a centralized database integrating healthcare supply chain stakeholders can take the efficiency to the next level along with increased resilience and risk mitigation through improved data visualization (LaPointe, 2020). Inventory databases might include data of expected number of daily refills, the storage space utilization and the service level of the stakeholders that can provide insights on ways to optimize inventory and purchasing (Leaven et al., 2017). Data is considered as the golden nugget in making proactive informed decisions by experts at Cardinal Health whose analytics can offer innovative healthcare systems more visibility into supply chain management issues, allowing for reduced costs and greater efficiencies (Damron, 2015; Lange, 2020). Here comes the importance of digital footprint data utilization from healthcare supply chain inventory databases whose management can monitor and provide information on ramping up of safety stocks for any unprecedented emergency situation through real time visualization of critical item inventory position that enables quick mitigation and stakeholder awareness. Hence, database management of digital footprint data of stakeholders' inventory can assess stock-on-hand, demand and desired quantity through collaboration within hospital and supplier base that can drive quick assessment of inventory gaps and trends and improve overall healthcare supply chain resiliency.

In this process, we can observe that the wholesaler controls the whole database system and the hospital authority. In the previous case, we can remember that wholesaler was unable to know the demand at the actual time. The wholesaler was informed about the demand when the authority of the hospital tried to inform. And at that time, wholesalers have to fulfill the demand without knowing the capacity of the wholesaler's inventory. When the wholesaler finds out the capacity he had, then he started packaging and delivering.

The main difference is that the wholesaler was unable to know the actual scenario of the hospital inventory earlier. The wholesaler used to know about the demand when the hospital authority informed him whether the needed product available in the hospital inventory or not. As a result, the needed medicine or product was becoming stock out at hospital at a certain period and it was becoming a very crisis moment until the new package arriving at the hospital from wholesaler. But with this solution the wholesaler will be monitoring the hospital inventory and his own inventory by the central database system every day and will be able to know about the amount of medicine present in the hospital inventory. By knowing this information, the wholesaler will be able to decide when to replenish the hospital's inventory with which product with exact amount needed. There is no chance of stock out of any product in the hospital inventory anymore. And the patient will get their service very well indeed which is the main priority for any healthcare organization.

5. Challenges and Limitations

Although digital footprint data analytics offer a wide range of opportunities to enhance healthcare supply chain performance through integrated database management in inventory monitoring, it also comes up with multiple challenges. This mainly occurs due to the criticality of the healthcare industry's inventory management, being different from other industries. The critical challenges in the path of implementing digital footprint database management in the healthcare supply chain can be illustrated as follows.

5.1. Digital Infrastructure Related Challenges

Having adequate infrastructure favoring the application of digital supply chain, integrating stakeholders' inventory data, usage of data analytics tools is a prerequisite for effective utilization of its potential that can optimize inventory management. In order to gain competitive advantages and take the journey forward, high speed and stable internet connectivity need to be ensured, which has been one of the key challenges to confront.

5.2 Mutual Conflicting Goals of Stakeholders

Stakeholders in the healthcare supply chain differ from their goals arising conflicts upon compliance of information sharing, accessibility that impedes in forming a transparent and collaborative network. Based on proper awareness programs and knowledge propagation of the benefits such as advanced risk prediction and greater supply chain visibility, this barrier can be brought to a minimalistic level, paving the way for compliance on database accessibility.

5.3. Data Safety and Cyber Security Concerns

To prevent harm to IT infrastructure and a firm's reputation, it's a challenge to keep digital assets secured and the stakeholders have to abide by data protection laws and privacies. For instance, different measures, such as secure cloud archiving and complaint cloud backup, need to be undertaken for safety concerns of their high-value information while extracting value from digital footprint making way for data management plans (*Digital Footprint Data Management*, 2020).

5.4. Lack of Trained Personnel in the Digital Healthcare Ecosystem

Digital footprint data has a lot of potential in managing the healthcare supply chain with improved efficiency through appropriate database management. To utilize such potentiality, needs of trained personnel with database management and data analytics skills is undeniable. Hence, managing data in a meaningful manner, from the onset of data collection, storage and exploration require trained professionals to make the best use of possibilities.

6. Conclusion and Future Research

This paper focuses on the implementation of efficient management of inventory undertaking VMI Approach through effective monitoring of inventory data generated from the digital footprint. Embracing modern technologies in inventory monitoring can have a positive consequential impact on low inventory control methods providing tremendous time and cost savings as well. A study reveals the adoption of data analytics-based inventory monitoring in Cardinal health has experienced an 84% improvement in time spent placing orders (Lange, 2020). Improved data analysis from the digital footprint of inventory order, replenishment, storage, and the delivery cycle can better aid in having enhanced visibility, predictability, and trend analysis. This can facilitate a dynamic digital supply chain design to reduce figures of 28% order delivery failure due to stock unavailability obtained from an analysis (Mustaffa & Potter, 2009). Hence, data-driven inventory management through collaboration utilizing digital footprint database management can analyses data patterns and support informed decision making among healthcare supply chain stakeholders improving overall system performance.

There are bright possibilities for future research in areas of streamlining patient care through the inclusion of patient specifics into the digital data ecosystem in addition to expanding the concept to transportation routing optimization with advanced data analytics leveraging enhanced sustainability, transparency, and traceability. The integration of a highly digitalized supply chain can create a better competitive advantage and more substantial economic ROI enabling data analytics leading to an optimized and resilient supply chain in the healthcare sector.

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