Forum For Economic Studies and Research Journal
Volume: 10/ N°: 01 (2026), p 351 - 370

Digitization Healthcare Supply Chain Management: Towards a Smarter and More Resilient System

Bouhadjeb Madjida [*1], Terbeche Mohamed [2]

[1] Laboratory LEPPESE Research , University Centre of Maghnia (Algeria), m.bouhadjeb@cu-maghnia.dz,

[2] Laboratory LEPPESE Research, University Centre of Maghnia (Algeria), moh_terbeche@yahoo.fr

Received: 10/01/2026 **Accepted: 17/05/2026**

Abstract:

This study aims to build an integrated framework for digitizing Healthcare Supply Chain Management by highlighting the differences between digital and traditional supply chains and the role of digital technologies in reshaping operations. It analyzed international experiences and the Saidal Group in Algeria, which implemented a pharmaceutical drug serialization project, showing that digitization improves logistics performance, enables accurate tracking of medical supplies, and reduces waste. The study concluded that digitization enhances traceability, lowers costs, improves transparency, and optimizes resource use. It also emphasized the importance of developing digital infrastructure, training human competencies, and adopting a gradual, participatory approach to ensure the success and sustainability of digital transformation in healthcare supply chains, particularly in the Algerian context,

Key Words: *Digitization, Supply Chain Management, Healthcare Supply Chain, Digital Technologies, Algeria.*

JEL Classification: *O33, M11, I18, O32, O55*

[*] - Corresponding author: **Bouhadjeb Madjida**, m.bouhadjeb@cu-maghnia.dz .

1. *Introduction*

In most countries, policymakers are highly concerned about the health sector. Although the sector is considered a clinical service-oriented environment, patient care delivery depends on a mix of processes that specifically encompass procurement, inventory management, and supply distribution to the point of care. These activities are related to healthcare supply chain management (SCM), often refered to as healthcare logistics. Improving the effectiveness of these logistics can provide opportunities for organizations and health systems to enhance the quality of care and reduce costs (Brian T, 2013, p. 465).

The healthcare industry has been criticized for lacking a deep understanding of SCM fundamentals, even though it is critical to the effective functioning of the healthcare system, ensuring that healthcare professionals are supplied with the equipment and supplies they require to trait their patients (Hiatt et al., 2024, p. 128). Therefore, SCM is a structure that includes different departments within an organization as well as different organizations, and it has been viewed from a functional perspective encompassing marketing, R&D, procurement, warehousing, manufacturing, sales, and finance (Ivanov et al., 2019, p. 7)

In light of digital transformation and the rapid digitization of the economy, organizations are increasingly required to adapt their management methods, functions, and culture to keep pace with these changes. The convergence of digital technologies with SCM has transformed traditional logistics into a technology-driven discipline, creating new opportunities for value creation. Through digital tools, supply chains achieve better inventory control, reduced waste, and improved distribution, which enhances healthcare quality and emergency responsiveness while promoting greater visibility, transparency, predictive analytics, and autonomous decision-making (Manal, 2024, p. 7).

Health organizations must proactively address challenges by adopting new methods and technologies. Despite the benefits of digitization, a gap remains in healthcare supply chain adoption, particularly in developing countries, due to issues such as poor infrastructure, lack of skilled personnel, limited funding, and weak inter-team cooperation. In Algeria, although digital transformation is advancing with supportive infrastructure and policies, efforts are ongoing to enhance digital capabilities, especially in the health sector, where the Ministry of Health, supported by the WHO, has adopted a national digitization strategy to integrate ICTs and achieve population health objectives (Al khoury, 2024, p. 86).

However, it still lags behind the experiences of developed countries in this field. Hence, the importance of this research, which aims to provide theoretical and applied insights on how to benefit from digitization in improving the healthcare supply chain. This is achieved by focusing on the latest practices and innovative methods, and analyzing international experiences, which allows for exploring ways to enhance digital performance in Algerian health institutions, while addressing the scarcity of studies that tackle this aspect in the Algerian context Against this backdrop, the following question arises:

How does digitizing healthcare supply chain management contribute to reshaping the management practices of health services in the Algerian healthcare sector?

1.1 Research Objectives

This study provides an in-depth insight into the digitization of healthcare supply chain management (HSCM), highlighting the distinction between traditional and digital models and offering an overview of the digital pillars and types of technologies applied to enhance the effectiveness and efficiency of healthcare supply chains. The paper also aims to examine the strengths and weaknesses of digitizing these chains and to draw lessons from successful international experiences to provide recommendations applicable to the development of the Algerian health sector.

1.2 Research Methodology

This study adopts a descriptive and analytical approach to present an integrated theoretical framework on healthcare SCM digitization, analyze key concepts and related technologies, and highlight successful international experiences. The content is organized sequentially, covering the introduction, research problem, literature review, concept definitions, differences between traditional and digital models, main pillars and challenges, and concluding with international case studies. Additionally, the study includes the Saidal Group in Algeria, showcasing its pharmaceutical drug serialization project as a practical local example

1.3 Literature Review

Over the past two decades, the healthcare sector has increasingly focused on digitizing supply chains to improve efficiency and effectiveness through advanced digital solutions. Scientific literature has examined this trend from various perspectives, including supply chain digitalization, the impact of specific technologies, and the factors influencing successful implementation. The following section provides an analytical review of the most relevant studies

Table 1. Summary of previous studies on supply chain digitization

Authors	Focal Point	Research Gap
(Ehie & Ferreira, 2019)	A conceptual framework explaining the relationship between supply chain digitization, logistics capabilities, and operational performance using the resource-based view	Develops Focuses on general supply chains without addressing the specific characteristics of healthcare supply chains.
(Sanders et al., 2019)	Examines the role of digital technologies and artificial intelligence in enabling sustainable supply chains and improving decision-making through real-time data and enhanced visibility	Does not specifically analyze the digitization of healthcare supply chains
(Seyedghorban et al., 2020)	A bibliometric and qualitative analysis of the evolution of supply chain research, highlighting the shift from RFID technologies toward big data and digital analytics.	Provides Offers a general overview of research trends without focusing on sector-specific applications such as healthcare supply chains.

(Frederico, 2021)	Proposes a strategic model for digitization-driven supply chains to enhance resilience and collaboration in the post-COVID-19 context.	Remains conceptual and does not examine specific sectors or developing country contexts.
(Chang et al., 2023)	Investigates the adoption of smart wearable technologies in omnichannel healthcare supply chains and the influence of ethical concerns such as privacy and security	Focuses on a specific technology rather than the broader digital transformation of healthcare supply chains
(Hiatt et al., 2024)	Reviews existing research in medical supply chain management and identifies emerging themes such as resilience, sustainability, and digital technologies including blockchain and RFID	Does not provide empirical evidence within specific national healthcare systems
(Hammam et al., 2024)	Examines the relationship between digitization and sustainability in pharmaceutical supply chains through reverse logistics in pharmacies	Limited to pharmacies in a specific region and does not address healthcare supply chains at the system level

Through the review of previous studies on supply chain digitization, it can be observed that the topic has been addressed from different perspectives in terms of methodology, geographical scope, and the dimensions of digital transformation. While some studies focused on developing conceptual frameworks to explain the evolution of supply chain digitization and its strategic implications, others adopted analytical approaches aimed at mapping existing knowledge and identifying emerging trends in the field.

For instance, the studies of Ehie & Ferreira (2019) and Frederico (2021) proposed conceptual models highlighting the role of digital technologies in improving supply chain performance and resilience. In contrast, studies such as Seyedghorban et al. (2020), Chang et al. (2023), and Hiatt et al. (2024) mainly relied on analytical reviews to examine the development of research and digital transformation trends in supply chain management. Moreover, Sanders et al. (2019) emphasized the relationship between digitization, sustainability, and supply chain resilience, particularly in times of crisis. On the other hand, Hammam et al. (2024) provided empirical evidence by analyzing the impact of digitization on supply chain performance in the pharmaceutical sector.

Overall, these studies provide a solid knowledge base on the digitization of supply chain management in the healthcare sector. However, despite the diversity of perspectives, limited attention has been given to the analysis of healthcare supply chain digitization in developing countries, particularly in the Algerian context. Therefore, this study aims to contribute to filling this gap by providing an analytical perspective adapted to the local context

2. *The Concept of Digitized Healthcare Supply Chain Management (DHSCM)*

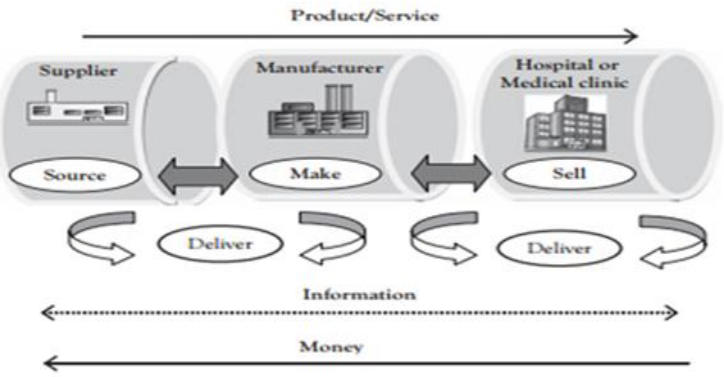
2.*1 Definition of Healthcare Supply Chain Management (HSCM)*

There are many definitions of SCM in the literature, reflecting different industry priorities. Since the emergence of the term "Supply Chain" in the early 1980s, its concept has evolved from focusing on the flow of goods to a systemic approach based on integration within and between organizations to create value for customers and stakeholders. In this context, Ford and Scanlon emphasize the importance of coordination and collaboration among stakeholders to understand customer priorities and the total cost of service (Schneller et al., 2023, p. 8).

- (Habib et al., 2022, p. 811) defines the HSC as a set of activities involving design, planning, purchasing, manufacturing, delivery, and return management, from the supplier to the recipient (patients), taking into account all patient paths within the hospital. Without this coordination, there would be no flow of products (medication). The coordination of these activities is carried out through the flow of information between the different partners in the SC, which also drives financial flows. This process aims to deliver the best service, ensuring the quality and safety of patient care
- The HSC represents the extensive global network of manufacturers, distributors, and healthcare providers, delivering goods and services to almost the entire global population. The variety of medical products and services introduces a significant level of complexity into the distribution of medical supplies. Consequently, the flow of medical products and services, as well as the movement of patients, must be regulated to facilitate the provision of high-quality healthcare services at a reduced cost (Hiatt et al., 2024, p. 129).
- Regarding the participants in the HSC,(Chen & Ruan, 2024, p. 110) identified four main parties forming the basis of the SC in the healthcare sector: Healthcare Organizations, Health Warehouses, Health Transportation Services, and Health Facilities. All these organizations operate as a system to facilitate the seamless delivery of health goods and services. Through this coordination, they contribute to the effective movement of health materials and services within the SC

Through the definitions provided, we conclude that the HSC is a set of interrelated and integrated functions at the level of the health institution and between it and other organizations, providing all health supplies necessary to deliver high-quality healthcare services. We illustrate this through the figure below, which shows the stages of the SC:

Fig.1. Stages of the Healthcare Supply Chain



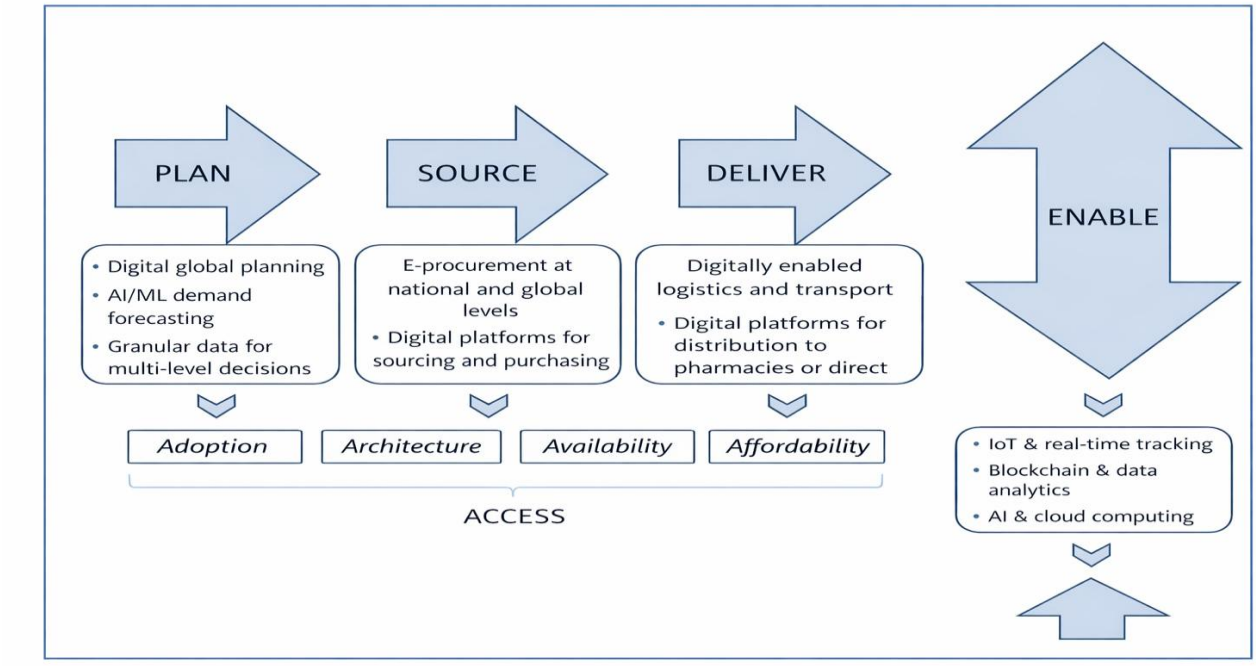
Source: (Hokey, 2014, p. 2)

2.2 *Digitization of Healthcare Supply Chain Management*

- Digitization is transforming how health organizations formulate healthcare Supply Chain Management strategies. Digital advancements enable the implementation of interdependent activities and the clear exchange of information among health organizations, service providers, and patients, increasing value for all SC parties. The digital health SC is an innovative, patient-centered, integrated, and data-driven system that improves accessibility and reduces costs. Its key benefits include speed, flexibility, connectivity, intelligence, transparency, and scalability(Seyedghorban et al., 2020, p. 4).
- Digital supply chains (DSC) are defined as smart value networks in which modern technologies and analytics generate new forms of value and revenue through a centralized system that uses real-time data from multiple sources. They rely on collaboration and effective communication between digital devices, software, and networks to facilitate organizational interaction and synchronization, enhance service value, ensure accessibility, and achieve flexible, efficient, and consistent performance (Garay-Rondero et al., 2020, p. 899).
- The digitization of the SC provides a cost-efficient solution that enables healthcare providers to deliver the right product to the right patient at the right time. It relies on technological advances in data flow and analysis, communication, asset monitoring, and regulatory compliance. Digitization leads to process redesign, standardization, innovation, improved collaboration and integration, greater transparency, enhanced responsiveness to demand and patient needs, and better decision-making, thereby supporting competitive advantage (SULTANOVA & AHMADOVA, 2024, p. 38).

Based on the previous definitions, we conclude that a smart and more flexible supply chain must rely on digital technology at all stages, allowing it to overcome traditional limitations and acquire a more efficient and responsive digital character, as illustrated in the following framework:

Fig.2. Conceptual framework of digital solutions in healthcare supply chains



Source: Adapted from (Yadav, 2024)

2.3 Traditional Versus Modern Methods of Healthcare Supply Chain Management

The digitization of the supply chain can be traced in two main stages: the first is the pre-digitization phase, which is characterized by the traditional nature of the chain organization and relies on traditional tools such as Excel, faxes; the second is the transition to digital functions, where digitization is used to improve individual processes and provide faster and more accurate services. This is illustrated in the following table:

Table 2. The digital evolution of the supply chain

Stage	Functionality	Pre-digital	Digital functions
Planning (Plan)	Demand planning	Excel based Planning/ Budget driven planning	Statistical forecasting of consumer demand
	Sales and Operations Planning (S&OP)	Ad-hoc alignment	Collaboration supported by ERP systems
	Delivery planning	Daily dispatch aplanning	Integration of 3PL
Sourcing (Source)	Purchase- to- pay	Phone and fax orders	Materials management order system
	Supplier Lifecycle Management	Mostly local sourcing	supply risk and performance oriented global supplier mgmt
Manufacturing (Make)	Scheduling	scheduling boards	Semi-automated scheduling for production planning
	Production	Serial production lines	Just-in-time (JIT) concepts
	Warehousing	High rack storage	Automated high-rack storage
Delivery (Deliver)	Orders Intake	2 nd level sales support	Order call center
	Spare parts management	Spare part inventory located at customer	Centralized spare parts warehouse with global 48-hour shipping
	Picking	Pick by picking list	Intelligent bundling of pick- orders
	Distribution	3 PL trucking	Cross-docking

Source:(Mrozek et al., 2020, p. 32)

2.4 The Pillars of the Digital Supply Chain (DSC)

The digital supply chain is built on five interconnected foundations that ensure integration and efficiency across its operations. These foundations include data, which enables data-driven decision-making; automation, which reduces manual tasks and improves operational efficiency; connectivity, which facilitates continuous communication among supply chain actors through digital networks; and artificial intelligence, which supports real-time analytics and decision-making. In addition, the future digital ecosystem emphasizes secure, resilient, and sustainable supply chains supported by advanced cybersecurity and sustainable practices (Mrozek et al., 2020, p. 24).

Figure .2. The Digital Supply Chain Pillars



Source: (Mrozek et al., 2020, p. 24).

3. Tools and Technologies for Digitizing the Healthcare Supply Chain Management

3.1 Barcoding Technology

Barcodes are a widely used automatic identification technology that provides a precise and cost-effective method for tracking products and managing information about goods and services. Most barcodes follow international standards, such as the GS1 system, ensuring universal acceptance for shipping and inventory purposes(In, 2014, p. 216).

In healthcare, barcodes help reduce time losses and errors in managing drug and material stocks. They prevent duplicate entries in inventory records, control reordering processes, and allow accurate monitoring of medication administration to patients (İyigün & Görçün, 2023, p. 17).

3.2 Radio Frequency Identification (RFID)

RFID (Radio Frequency Identification) is a key technology for managing healthcare supply chains by automatically identifying and tracking materials using radio waves (İyigün & Görçün, 2023, p. 16).

In hospitals, RFID enables the monitoring of medical equipment, tracking of usage, quick location of items, and verification of compatibility for safe use. Unlike barcodes, RFID provides non-contact identification, does not require a line of sight, and allows rapid reading of multiple tags simultaneously, which improves inventory accuracy, reduces delays, lowers costs, shortens patient wait times, and minimizes medical errors. While the technology enhances data collection and resource management, it also poses privacy risks related to the tag-reader system and external data sharing(Mohamed K, 2011, p. 75.78).

3.3 Internet of Things (IOT)

The Internet of Things (IoT) refers to the interconnection of devices often without traditional networking to enable smart applications through software and automated actions. Technologies such as RFID tags facilitate connectivity and metadata exchange. In supply chain management, IoT involves interconnected physical objects capable of sensing, tracking, and communicating within and across organizations, thereby enhancing flexibility, visibility, traceability, and information sharing for real-time planning and coordination of supply chain activities (Rejeb et al., 2020, p. 3).

In healthcare supply chains, IoT supports several key applications. It enables real-time inventory monitoring through sensors and RFID, improving efficiency and reducing costs. It also enhances asset tracking by allowing real-time monitoring of equipment, vehicles, and goods using GPS and RFID technologies. Additionally, IoT ensures continuous monitoring of

temperature-sensitive products, such as pharmaceuticals, preserving their quality throughout the supply chain. It further contributes to waste reduction and sustainability by optimizing resource use, and supports predictive maintenance by identifying potential issues in advance, thereby reducing downtime and extending asset life (Sallam et al., 2023, p. 7.8.9).

Overall, IoT facilitates real-time data exchange, improves patient care, reduces operational costs, and supports more accurate clinical decision-making. However, its implementation in healthcare supply chains faces several challenges, including architectural complexity, high costs, lack of skilled personnel, regulatory constraints, data management issues, and inadequate internet and IT infrastructure (Desingh & R, 2022, p. 233).

3.4 Blockchain technology

Blockchain technology is a promising tool for healthcare supply chains due to its ability to enhance data security, transparency, and traceability ((Kavita & J.N, 2024, p. 7). By maintaining an immutable and decentralized digital ledger, blockchain ensures that all transactions from pharmaceutical production to delivery are securely recorded and easily verifiable. Its key features, including decentralization, immutability, traceability, privacy, and smart contracts, support secure end-to-end management of healthcare products(Patrick et al., 2024, p. 2).

In practice, blockchain enables accurate tracking of medicines, reduces the risk of counterfeit products, improves real-time visibility, and ensures that genuine medical supplies reach patients efficiently (Peng, 2024, p. 20).

3.5 3D Printing

The International Organization defines additive Manufacturing (AM), commonly known as 3D printing, for Standardization (ISO, 2017) as a process that builds products layer by layer rather than through subtractive methods like cutting or drilling. In supply chains, AM has been applied to spare parts logistics and the reconfiguration of production strategies, offering greater manufacturing flexibility, shorter delivery times, product customization, and lower inventory levels (Ivanov et al., 2019, p. 502).

In healthcare, 3D printing is used to produce accurate anatomical models from cross-sectional images, helping surgeons visualize procedures during preoperative planning. These models provide practical solutions that were previously unavailable. However, adoption is still limited to a few hospitals, affecting supply and demand dynamics.

Challenges in developing 3D-printed medical model supply chains include limited material options, high costs of biocompatible materials, and variability in model accuracy. Production remains slow and expensive for customized models, and effective implementation requires skilled personnel, reliable diagnostic data, and precise imaging. Additional barriers include the high cost of CT and MRI scans, the need for specialized data analysis and design expertise, software limitations, and slow regulatory approval, all of which hinder widespread adoption(Verma et al., 2022, p. 290.296).

3.6 Artificial Intelligence (AI)

Artificial Intelligence (AI) refers to the ability of machines to emulate human actions, making it suitable for tasks requiring precision and speed, particularly in SCM. It is widely used in manufacturing, with artificial neural networks part of machine learning being among the most common technologies. Machine learning enables the processing of large volumes of data in

supply chains, allowing process automation, cost reduction, and accurate predictions.(Bigliardi et al., 2022, p. 1808).

Its main applications are as follows:(Long et al., 2023, p. 4)

- **Pharmaceutical R&D:** AI is used to analyze large amounts of data using appropriate algorithmic models, which contributes to accelerating drug development, reducing costs, and increasing success rates in research and trials.
- **Enhancing the sustainability of the health SC:** AI supports supply chain continuity by enabling rapid and effective decision-making, thereby minimizing potential disruptions.
- **Healthcare SCM:** AI is used to optimize the management of this complex system, improving economic performance while considering the interests of all stakeholders involved in the supply chain.
- **Demand forecasting and patient tracking:** AI analyzes patient data and compares it with benchmarks, enabling accurate predictions and supporting decision-making in supply and care

The use of AI in healthcare supply chains faces several limitations, particularly its limited adoption compared to other sectors due to legal restrictions and privacy requirements. Research often emphasizes technical and ethical aspects but provides insufficient guidance on integrating AI into practical work environments. Moreover, academic understanding is largely restricted to disease surveillance and drug development, limiting the technology's applied value**.**

3.7 Big Data (BD)

A wide range of physical devices generates and shares large volumes of data that cannot be processed using conventional methods, making Big Data analytics a key component in supply chain management. This has transformed IoT-based supply chains into data-driven systems that enable large-scale analysis and improve efficiency (Mac Carthy & Ivanov, 2022, p. 68).

Big Data is defined as an information asset characterized by high volume, velocity, and variety, requiring advanced analytical techniques to create value. According to the McKinsey Global Institute, it refers to data that cannot be effectively managed, analyzed, or stored using traditional database systems (Bahri et al., 2019, p. 7398).

The use of Big Data Analytics (BDA) in operations and healthcare SCM offers significant benefits, including improved operations, cost reduction, enhanced service quality, better decision-making, optimized resource use, and improved management of patient pathways and logistics (Benzidia et al., 2023, p. 1081).

However, several challenges persist. Data quality remains a major issue due to multiple unstructured sources such as prescriptions and medical notes. Confidentiality and legal restrictions also limit data sharing. In addition, the lack of experts, limited applied studies, system incompatibility, and difficulties in integrating heterogeneous datasets pose significant technical challenges (Bhatia & Mittal, 2019, p. 884.885).

After presenting the various digital technologies, their benefits and associated challenges, we concluded that the use of these technologies in health SCM is a pivotal step towards enhancing efficiency and achieving integration between the various actors in the health system.

4. The Benefits and Challenges of Digitizing the Healthcare Supply Chain

4.1 Benefits

An effective digital HSC can enhance patient care while reducing costs. Digitization goes beyond using traditional information systems or introducing advanced technologies; it involves transforming healthcare services to serve patients more efficiently. As a result, various innovative technologies have been adopted to improve healthcare supply chains, making the development of smart and digital systems a priority for modernizing healthcare services. (Monferdini et al., 2024, p. 2227).

The use of these technologies is associated with numerous advantages: (Büyüközkan & Göçer, 2018, p. 167) , (Hokey, 2014, p. 123)

- **Patient-centeredness:** The ability to maintain a more interactive relationship between healthcare professionals and patients.
- **Timely response:** The capacity to address patient needs in a timely manner, This requires an agile, healthcare that eliminates redundant processes and adopts lean principles such as "just-in-time".
- **Real-time information sharing:** The ability to share accurate information with patients and stakeholders in real time, supporting timely and informed decision- making. In this context, EHR and mobile technologies play an important role in the healthcare SC.
- **Error-free:** The ability to minimize risks and medical errors, including prescription errors and SC disruption (e.g., shortages or delays), through integrated systems such as automation and reduced human intervention.
- **Traceability:** The capacity to trace sources of problems such as counterfeit drugs or contaminated products, to enhance patient safety and quality of care.
- **Scalability:** The ability to respond to increased demand for healthcare services, particularly for specific groups such as the elderly or uninsured populations, while supporting economies of scale and reducing costs.
- **Collaboration:** The alignment of capabilities both internally and externally to improve cooperation among supply chain stakeholders.
- **Integration:** The integration of digital and non-digital supply chain processes, enabling a comprehensive view of operations both inside and outside the organization.
- **Faster innovation:** Digital supply chains promote innovation in design, operations, and relationships with healthcare providers.
- **Proactive prevention:** Decision support systems using predictive analytics enhance supply chain resilience and adaptability

Digitalization of the HSC is a promising research field that can provide significant contributions to health systems worldwide; however, it is currently hindered by several challenges that need to be addressed.

4.2 Challenges

Despite the great potential of digitization to transform the HSC, this path is not without challenges and difficulties. Recognizing these challenges, understanding their causes, and finding appropriate solutions are essential to ensure the effective and seamless integration of digital technologies. When analyzing these obstacles, they can be categorized into three main

areas that need to be addressed promptly: limited infrastructure, lack of skills and knowledge, and regulatory and policy concerns (Ashiwaju et al., 2023, p. 99).

- **Infrastructure limitations** represent a major challenge to digital transformation and remain uneven, particularly in Africa. While some regions experience rapid urbanization and capacity growth, others still face fundamental constraints, creating disparities in the adoption of advanced digital solutions. Despite improvements in digital infrastructure coverage and service quality, the limited availability of high-speed internet in certain areas continues to hinder cloud-based systems and real-time data exchange. In addition, the lack of robust local data centers forces many platforms to rely on offshore facilities, raising concerns related to latency and data sovereignty (Ashiwaju et al., 2023, p. 99)**.**

In this context, Algeria is continuously making progress, with a digital infrastructure index of 51.05, according to the Arab Digital Economy Index 2024. The digital infrastructure has been modernized to support high-speed internet and advanced telecommunications services nationwide by expanding the fiber-optic network, drawing on the experiences of several countries and relying on sustained efforts to develop existing capabilities (Al khoury, 2024, p. 325).

- The lack of skills and knowledge remains a major challenge in adopting advanced technological tools, as their effectiveness depends on the availability of qualified personnel. In many parts of Africa, a shortage of specialized talent persists due to historical underinvestment in STEM education and the absence of training programs adapted to the specific needs of healthcare supply chains. Moreover, the rapid evolution of technology often exceeds the pace of curriculum updates, creating a gap between academic training and field requirements.

To address this issue, short-term solutions include intensive training programs and workshops conducted in collaboration with international technological institutions, while long-term strategies require curriculum reform, strengthened scientific research, and the establishment of centers of excellence specializing in digital supply chain technologie**s** (Ashiwaju et al., 2023, p. 100).

In this context, Algeria is working to provide education and training in the fields of computing and digital technologies through universities and institutes, contributing to the development of human capabilities that support innovation and technological advancement, enhancing digital literacy, and creating a qualified workforce. Algeria's labor force index reached 27.39 in 2024 (Al khoury, 2024, p. 326).

- **Organizational and policy** concerns represent another major barrier to digital transformation in healthcare, particularly regarding privacy and cybersecurity. In some cases, regulations intended to protect stakeholders may unintentionally hinder digital adoption. For example, strict data localization laws can limit the use of cloud platforms that rely on offshore data centers, while weak data protection legislation may discourage organizations from adopting digital solutions due to potential legal risks. Additionally, the novelty of these technologies means that some countries still lack comprehensive regulatory frameworks, creating uncertainty that may deter investment in digital transformation projects(Ashiwaju et al., 2023, p. 100).

To address these challenges, a collaborative approach involving governments, industry leaders, technical experts, and international regulatory authorities is required to develop policies that balance innovation and protection, ensuring that legal frameworks support rather than hinder technological progress. Accordingly, building a digitized and smart healthcare supply chain requires cooperation among all internal and external actors in the health system to establish a flexible and efficient supply network

5. Successful International Experiences in Digitizing Health SCM through the Application of Digital technologies

5.1 Hospices Civils de Lyon, France

Hospices Civils de Lyon in France has successfully implemented a TotalSense RFID system to manage implanted medical devices in its interventional cardiology department, aiming to improve traceability, enhance safety, and ensure compliance with European regulations. The organization used smart cabinets equipped with RFID tags, mobile systems, and applications linked to the IdentiPlatform cloud-based platform to record GTINs, track serial numbers, and monitor expiration dates.

The initiative yielded significant results, including a 91% compliance rate with European UDI regulations, a 37% reduction in inventory levels, and a 50% decrease in overstocked products within the first eight months. Incidents involving expired devices were eliminated, compared to 52% of pharmacists reporting such incidents prior to implementation. The system also reduced ordering time by 3 hours per week and improved coordination between the pharmacy and medical services departments.

Through this digital system, the hospital was able to ensure full compliance with EU MDR 2017/745 and achieve accurate, real-time lifecycle tracking of medical devices, enabling it to enhance operational efficiency, reduce costs, and improve patient safety (https://identimedical.com, 2024).

5.2 MediLedger - DSCSA Project in the United States:

The MediLedger project and the Drug Supply Chain Security Act (DSCSA) pilot project in the United States are notable international examples of success in digitizing the healthcare supply chain. The MediLedger project uses blockchain technology to create a decentralized and secure ledger that enables real-time tracking of medicines and prevents tampering, thereby reducing the circulation of counterfeit drugs and improving supply chain efficiency.

The U.S. Food and Drug Administration (FDA) initiative under the DSCSA aims to enhance supply chain security through serialization and verification of drug authenticity, using pilot programs to evaluate traceability and interoperability technologies among stakeholders. These initiatives have demonstrated the importance of collaboration between manufacturers, distributors, and pharmacies to ensure compliance, safety, and the effectiveness of pharmaceutical products (Innovation.io, s. d.).

5.3 The Pharma Ledger Experience in Switzerland

In 2022, the PharmaLedger Association (PLA), a global non-profit organization based in Basel, Switzerland, launched an initiative to leverage blockchain and IoT technologies to build a digital trust ecosystem in the healthcare supply chain. At ASCM Connect Europe in Brussels, it presented its innovative Digital Trust Ecosystem (DTE), a collaborative network of

stakeholders using secure and standardized digital solutions for mutual benefit, within a "Healthcare 4.0" model based on transparency and trust.

This initiative focuses on ensuring patient-centered value through secure, efficient, and transparent solutions. One of its most prominent projects is the Supply Chain Traceability Project, which enhances transparency and reliability in the delivery of pharmaceutical products by utilizing blockchain to provide end-to-end traceability from source to consumer.

The project includes the development of two main components: "Clinical Supply Chain Traceability," which provides an auditable platform that tracks products from supply to the point of consumption; and "End Product Traceability," which connects supply chain actors and accelerates information exchange within a unified digital ecosystem. The platform is open-source, allowing for continuous development by the global developer community (GmbH, 2023).

5.4 FarmaTrust Experience in the UK

FarmaTrust is a privately held UK company founded in 2017 and headquartered in London (81 Chancery Lane). The platform uses blockchain and artificial intelligence to improve transparency in pharmaceutical supply chains by creating a permanent, immutable record to track the movement of medicines from manufacturing to the end consumer. FarmaTrust aims to combat counterfeit medicines, reduce costs, and enhance consumer trust. In 2018, the company collaborated with the government of Mongolia to launch a national pilot project aimed at reducing the entry of counterfeit medicines into the market, using digital solutions built on data tracking (FarmaTrust, s. d.).

5.5 AP-HP Hospital Paris

During the COVID-19 pandemic, France, represented by the University Hospital Centre (AP-HP) in Paris, relied on 3D printing as an innovative digital solution to strengthen the healthcare supply chain, as traditional channels were disrupted. The Centre invested in 60 Strategy F123 3D printers, enabling it to quickly become self-sufficient by producing thousands of essential parts on-site, including face shields, protective masks, infusion pumps, intubation equipment, and respiratory valves.

This approach allowed the hospital system to bypass reliance on traditional suppliers and respond immediately to emergency medical needs. After the crisis, these printers were distributed across AP-HP's network of hospitals, creating a distributed manufacturing ecosystem that promotes rapid adaptability in future emergencies while enabling local hospitals to produce customized medical models, thereby improving the quality of healthcare services (Industry EMEA, 2021).

While several international experiences demonstrate the successful application of digital technologies in healthcare supply chains, similar initiatives are gradually emerging in developing countries. In Algeria, the Saidal Group has taken significant steps toward digitizing the pharmaceutical supply chain through the implementation of a drug serialization project

5.6 *The Saidal Group Experience in Algeria in Digitizing the Pharmaceutical Supply Chain*

**Overview of the Saidal Group*

The Saidal Group is one of the most important public enterprises specializing in pharmaceutical manufacturing in Algeria. Since its establishment, the group has developed a significant industrial base that has enabled it to meet a substantial portion of the national

pharmaceutical market's needs. Its production system relies on several manufacturing units strategically distributed across different regions of the country, which enhances production capacity and facilitates the nationwide distribution of medicines.

The group also places great importance on compliance with pharmaceutical standards at all stages of production, including manufacturing, quality control, and pharmacovigilance. This commitment has strengthened the confidence of healthcare institutions and consumers in locally produced medicines. In addition, the Saidal Group continues to invest in technological development and in strengthening the skills of its human resources in order to keep pace with the rapid developments in the global pharmaceutical industry (almurakib.com, 2025)

Pharmaceutical Drug Serialization Project

As part of the ongoing digital transformation in the healthcare sector, the Saidal Group launched a pharmaceutical drug serialization project in January 2025 at its manufacturing facility in Cherchell, with the aim of enhancing drug traceability and ensuring the safety of pharmaceutical products throughout the different stages of the healthcare supply chain.

The project was officially announced in the presence of several government officials, including Saifi Ghrieb, Minister of Industry and Pharmaceutical Production, Meriem Benmouloud, High Commissioner for Digitization, and the Chief Executive Officer of the Saidal Group, Wassim Kouidri. This initiative reflects the national orientation toward integrating digital technologies into the management of the pharmaceutical sector and strengthening transparency and monitoring in the circulation of pharmaceutical products within the national market (barakanews.dz, s. d.)

Concept of Pharmaceutical Serialization

Pharmaceutical serialization refers to the process of assigning a unique and non-replicable code to each individual package of medicine produced. This code enables the tracking of pharmaceutical products throughout all stages of the supply chain, from production or importation, through distribution and storage, to pharmacies and the final consumer.

The system relies on two-dimensional digital codes linked to a centralized database, allowing accurate identification of pharmaceutical products and verification of their authenticity. This technology has become an internationally recognized standard for combating counterfeit medicines and ensuring patient safety.

Benefits and Strategic Importance of the Project

The implementation of a digital drug traceability system provides several important benefits for the healthcare supply chain, including:

- Enhancing patient safety by ensuring the authenticity of circulating medicines.
- Improving transparency and traceability within the pharmaceutical supply chain.
- Facilitating the recall of pharmaceutical products in case defects are detected.
- Reducing the spread of counterfeit or illegally distributed medicines.
- Improving the management of drug expiration dates and reducing waste.
- Supporting pharmacovigilance systems through more accurate drug-related data.
- Providing reliable data that can support decision-making and healthcare policy development.

From a strategic perspective, this project represents an important step toward modernizing the pharmaceutical industry in Algeria and strengthening the reliability of the healthcare supply chain. It also opens new opportunities for national pharmaceutical companies, particularly the

Saidal Group, to integrate into international markets that require advanced standards for pharmaceutical traceability and quality (saidalgroup.dz, s. d.)

5.7 Analysis of International and Algerian Experiences

International experiences demonstrate that digital technologies such as RFID, 3D printing, and blockchain significantly enhance traceability, transparency, and supply chain efficiency. For example, Hospices Civils de Lyon and MediLedger improved product tracking and reduced risks from counterfeit or expired items, while AP-HP's 3D printing initiative during COVID-19 highlighted the value of flexible and distributed manufacturing to respond rapidly to emergencies.

In Algeria, the Saidal Group's drug serialization project reflects a promising initial step toward digitizing the pharmaceutical supply chain, aligning with global trends. However, challenges such as limited infrastructure, skill gaps, and regulatory barriers remain and must be addressed.

These cases collectively indicate that successful digitalization requires collaboration among stakeholders, adoption of scalable and open technologies, and strategic investment in infrastructure and human resources. By learning from international best practices, Algeria can enhance supply chain resilience, efficiency, and patient-centered outcomes while gradually expanding its digital capabilities

6. Conclusion*:*

This study examined the digitization of healthcare SCM, building on previous research to present an integrated theoretical framework tailored to the Algerian health context. The insights gained from international experiences and the local Algerian context provide a practical foundation for shaping recommendations and strategies to enhance the digitization of healthcare supply chains in Algeria. It covered the concepts of healthcare SCM, distinguished it from digital supply chains, outlined the main pillars, and analyzed key digital technologies that optimize planning, procurement, storage, distribution, tracking, and decision-making, thereby enhancing service continuity and patient safety. To make the study more practical and relevant, successful international experiences were reviewed, along with the Saidal Group in Algeria, showcasing its pharmaceutical drug serialization project as a local practical example.

Key outcomes include:

- Increased flexibility and readiness of healthcare supply systems to handle crises and emergencies.
- Cost reduction through minimized waste, reduced excess inventory, and efficient resource use.
- Improved traceability and transparency of medicines and medical supplies, reducing counterfeiting and misuse.
- Enhanced regulatory compliance, particularly in medical device tracking.
- Greater efficiency for medical and administrative staff by reducing inventory and verification burdens.
- Integration of supply chain actors via unified digital platforms.
- Real-time data availability to support accurate and proactive decision-making.

Recommendations for the Algerian health sector:

- Invest in digital infrastructure and ensure continuous maintenance and modernization.
- Pilot digital systems in reference hospitals before national implementation.
- Build partnerships with private and technology sectors to accelerate adoption at lower costs.

- Provide ongoing training for medical and administrative staff in digital tools and SCM technology.
- Establish a regulatory body or digitization unit to guide and coordinate efforts.
- Adopt a gradual approach to digitization, starting with hospital priorities and expanding progressively.
- Leverage international experiences and adapt them to local capabilities and context rather than copying them directly.

7. *Bibliography List:*

Al khoury, D. Mohamed. A. (2024, août 12). المؤشر العربي للاقتصاد الرقمي 2024. Arab Digital Economy Federation. https://arab-digital-economy.org/?p=11838

almurakib.com. (2025, décembre 24). صيدال | شركة صناعات دوائية. المراقب. https://almurakib.com/صيدال-شركة-صناعات-دوائية/

Ashiwaju, B. I., Agho, M. O., Okogwu, C., Orikpete, O. F., & Daraojimba, C. (2023). Digital Transformation in Pharmaceutical Supply Chain : An African Case. Matrix Science Pharma, 7(3), 95. https://doi.org/10.4103/mtsp.mtsp_16_23

Bahri, S., Zoghlami, N., Abed, M., & Tavares, J. M. R. S. (2019). BIG DATA for Healthcare : A Survey. IEEE Access, 7, 7397-7408. IEEE Access. https://doi.org/10.1109/ACCESS.2018.2889180

barakanews.dz. (s. d.). صيدال" تطلق مشروع تكنولوجيا التسلسل الصيدلاني للأدوية"—Baraknews. Consulté 13 mars 2026, à l'adresse https://barakanews.dz/posts/sydal-ttlk-mshroaa-tknologya-altslsl-alsydlany-lladoy

Benzidia, S., Bentahar, O., Husson, J., & Makaoui, N. (2023). Big Data Analytics Capability in Healthcare Operations and Supply Chain Management : The Role of Green Process Innovation. Annals of Operations Research, (1077-1101), 25 p. https://doi.org/10.1007/s10479-022-05157-6

Bhatia, A., & Mittal, P. (2019). Big Data Driven Healthcare Supply Chain : Understanding Potentials and Capabilities (SSRN Scholarly Paper N° 3464217). Social Science Research Network. https://doi.org/10.2139/ssrn.3464217

Bigliardi, B., Filippelli, S., Petroni, A., & Tagliente, L. (2022). The digitalization of supply chain : A review. Procedia Computer Science, 3rd International Conference on Industry 4.0 and Smart Manufacturing, 200, 1806-1815. https://doi.org/10.1016/j.procs.2022.01.381

Brian T, D. (2013). Handbook of Healthcare Operations Management : Methods and Applications—PDF Drive. Springer Science+Business Media. https://www.pdfdrive.com/handbook-of-healthcare-operations-management-methods-and-applications-e157397101.html

Büyüközkan, G., & Göçer, F. (2018). Digital Supply Chain : Literature review and a proposed framework for future research. Computers in Industry, 97, 157-177. https://doi.org/10.1016/j.compind.2018.02.010

Chang, V., Doan, L. M. T., Ariel Xu, Q., Hall, K., Anna Wang, Y., & Mustafa Kamal, M. (2023). Digitalization in omnichannel healthcare supply chain businesses : The role of smart wearable devices. Journal of Business Research, 156, 113369. https://doi.org/10.1016/j.jbusres.2022.113369

Chen, Z.-S., & Ruan, J.-Q. (2024). Metaverse healthcare supply chain : Conceptual framework and barrier identification. Engineering Applications of Artificial Intelligence, 133, 108113. https://doi.org/10.1016/j.engappai.2024.108113

Desingh, V., & R, B. (2022). Internet of Things adoption barriers in the Indian healthcare supply chain : An ISM-fuzzy MICMAC approach. The International Journal of Health Planning and Management, 37(1), 318-351. https://doi.org/10.1002/hpm.3331

Ehie, I., & Ferreira, L. M. D. F. (2019). Conceptual Development of Supply Chain Digitalization Framework. IFAC-PapersOnLine, 9th IFAC Conference on Manufacturing Modelling, Management and Control MIM 2019, 52(13), 2338-2342. https://doi.org/10.1016/j.ifacol.2019.11.555

FarmaTrust. (s. d.). FarmaTrust 2025 Company Profile : Valuation, Funding & Investors | PitchBook. Consulté 5 juillet 2025, à l'adresse https://pitchbook.com/profiles/company/469116-82

Frederico, G. F. (2021). Towards a Supply Chain 4.0 on the post-COVID-19 pandemic : A conceptual and strategic discussion for more resilient supply chains. Rajagiri Management Journal, 15(2), 94-104. (world). https://doi.org/10.1108/RAMJ-08-2020-0047

Garay-Rondero, C. L., Martinez-Flores, J. L., Smith, N. R., Morales, S. O. C., & Aldrette-Malacara, A. (2020). Digital supply chain model in Industry 4.0. Journal of Manufacturing Technology Management, 31(5), 887-933. (world). https://doi.org/10.1108/JMTM-08-2018-0280

GmbH, P. P. M. I. (2023, juillet 21). Blockchain and Internet of Things (IoT) to revolutionize healthcare. https://www.pmi-m.de/en/about-us/news/detail/blockchain-and-internet-of-things-iot-to-revolutionize-healthcare/?utm_source=chatgpt.com

Habib, M. M., Chowdhury, F., Sabah, S., & Debnath, D. (2022). A Study on Hospital Supply Chain Management. American Journal of Industrial and Business Management, 12(5), Article 5. https://doi.org/10.4236/ajibm.2022.125042

Hammam, K. H. A. E. H., ELSakty, P. D. K. G., & Suleiman, D. A. M. S. (2024). The effect of Digitalization on Pharmaceutical Supply Chain Sustainability Apply on Reverse Logistics of Pharmacies in Aswan. *المجلة العلمية للدراسات والبحوث المالية والإدارية*, 16(2), 771-803. https://doi.org/10.21608/masf.2023.228325.1060

Hiatt, B., Hong, S.-J., Kwon, I.-W., & Savoie, M. (2024). Digitalization and the Medical Supply Chain Management : Systematic Literature Review and Bibliometric Analysis. Operations and Supply Chain Management: An International Journal, 17(3), 128-140. https://doi.org/10.31387/oscm0580431

Hokey, M. (2014). Healthcare supply chain management : Basic concepts and principles [2014]. Business Expert Press. http://www.pdfdrive.com/healthcare-supply-chain-management-basic-concepts-and-principles-e157953419.html

https://identimedical.com. (2024, avril 21). French Case Study medical device tracking technology. https://identimedical.com/french-case-study-l-medical-device-tracking-tech/

In, L. (2014). RFID Technology Integration for Business Performance Improvement. IGI Global.

Industry EMEA. (2021, juin 17). How 3D Printing Could hold the key to Ensuring Supply Chain Resiliency and Production Flexibility. Industry EMEA.

https://www.industryemea.com/technical-articles/42369-how-3d-printing-could-hold-the-key-to-ensuring-supply-chain-resiliency-and-production-flexibility

Innovation.io, R. (s. d.). 16 Groundbreaking Blockchain Healthcare Examples in 2025. Consulté 4 juillet 2025, à l'adresse https://www.rapidinnovation.io/post/blockchain-in-healthcare-real-world-examples?utm_source=chatgpt.com

Ivanov, D., Tsipoulanidis, A., & Schönberger, J. (2019). Global Supply Chain and Operations Management : A Decision-Oriented Introduction to the Creation of Value - PDF Drive [Second Edition]. the registered company Springer Nature Switzerland AG. http://www.pdfdrive.com/global-supply-chain-and-operations-management-a-decision-oriented-introduction-to-the-creation-of-value-e187216737.html

İyigün, İ., & Görçün, Ö. F. (2023). Health 4.0 and Medical Supply Chain. Springer Nature.

Kavita, S., & J.N, S. (2024). Blockchain and IoT Approaches for Secure Electronic Health Records (EHR). IGI Global.

Long, P., Lu, L., Chen, Q., Chen, Y., Li, C., & Luo, X. (2023). Intelligent selection of healthcare supply chain mode – an applied research based on artificial intelligence. Frontiers in Public Health, 11. https://doi.org/10.3389/fpubh.2023.1310016

Mac Carthy, B. L., & Ivanov, D. (2022). The Digital Supply Chain. Elsevier.

Manal, B. A. (2024). Revolutionizing Supply Chains Through Digital Transformation. IGI Global.

Mohamed K, W. (2011). E-Healthcare Systems and Wireless Communications : Current and Future Challenges: Current and Future Challenges. IGI Global.

Monferdini, L., Pini, B., Bigliardi, B., & Bottani, E. (2024). Challenges and opportunities of digitalization in the healthcare supply chain : A literature review. Procedia Computer Science, 5th International Conference on Industry 4.0 and Smart Manufacturing (ISM 2023), 232, 2220-2229. https://doi.org/10.1016/j.procs.2024.02.041

Mrozek, T., Seitz, D., Gundermann, K.-U., & Dicke, M. (2020). Digital Supply Chains : A Practitioner's Guide to Successful Digitalization. Campus Verlag.

Patrick, D., Julie, D., & Garth V, C. (2024). (PDF) Blockchain Technology for Global Supply Chain Management : A Survey of Applications, Challenges, Opportunities & Implications (March 2024). ResearchGate. https://doi.org/10.1109/ACCESS.2024.3399759

Peng, L. A. K., D. Karthika Renuka, Sonali Agarwal, Sheng-Lung. (2024). Blockchain and IoT based Smart Healthcare Systems. Bentham Science Publishers.

Rejeb, A., Simske, S., Rejeb, K., Treiblmaier, H., & Zailani, S. (2020). Internet of Things research in supply chain management and logistics : A bibliometric analysis. Internet of Things, 12, 100318. https://doi.org/10.1016/j.iot.2020.100318

saidalgroup.dz. (s. d.). Groupe Saidal—📌صيدال يطلق 2025 جانفي 27 شرشال، بيان صحفي .. | Facebook. Consulté 10 mars 2026, à l'adresse https://www.facebook.com/groupesaidal

Sallam, K., Mohamed, M., & Wagdy Mohamed, A. (2023). Internet of Things (IoT) in Supply Chain Management : Challenges, Opportunities, and Best Practices. Sustainable Machine Intelligence Journal, 2. https://doi.org/10.61185/SMIJ.2023.22103

Sanders, N. R., Boone, T., Ganeshan, R., & Wood, J. D. (2019). Sustainable Supply Chains in the Age of AI and Digitization : Research Challenges and Opportunities. Journal of Business Logistics, 40(3), 229-240. https://doi.org/10.1111/jbl.12224

Schneller, E., Abdulsalam, Y., Conway, K., & Eckler, J. (2023). Strategic Management of the Healthcare Supply Chain. John Wiley & Sons.

Seyedghorban, Z., Tahernejad, H., Meriton, R., & Graham, G. (2020). Supply chain digitalization : Past, present and future. Production Planning & Control, 31(2-3), 96-114. https://doi.org/10.1080/09537287.2019.1631461

SULTANOVA, R., & AHMADOVA, T. (2024). DIGITAL SOLUTIONS FOR SUPPLY CHAIN MANAGEMENT IN HEALTHCARE. Journal of Baku Engineering University, 8(1), 34. https://doi.org/https://doi.org/10.30546/2521-6341.8.2024.006

Verma, V. K., Kamble, S. S., & Ganapathy, L. (2022). 3D-printed medical models supply chain : Barriers modeling and analysis. Rapid Prototyping Journal, 29(2), 288-311. (world). https://doi.org/10.1108/RPJ-11-2021-0312

Yadav, P. (2024). Digital Transformation in the Health Product Supply Chain : A Framework for Analysis. Health Systems & Reform, 10(2), 2386041. https://doi.org/10.1080/23288604.2024.2386041