The Impact of Digital Supply Chain on the Pharmaceutical Industry Performance in the Post-Pandemic Era: A Case Study for JDL

Ruobing Zhang

Wenzhou-Kean University, China
zhanruob@kean.edu

Abstract: The COVID-19 epidemic had a tremendous impact on both the worldwide economy and society, differing to varying degrees in major economies all over the world. This study investigates how disruptive technologies like digital technology affect JD Logistics' performance in pharmaceutical supply chains and to find out how JD Logistics used digital supply chain tactics during the COVID-19 epidemic and how it responded to the lessons learned in terms of innovation. Using multiple online resources, such as websites and blogs, that guide and review the solutions done by JD Logistics and other leading companies with case study analysis. The study includes both theoretical and practical insights regarding the deployment of the digital supply chain in the post-pandemic age. It is found that the supply chain service of resource network, operation standardization, quality compliance, and process visualization are essential to pharmaceutical logistics. This paper enhances the existing body of knowledge by outlining potential areas for future studies into how the management and performance of a firm with a pharmaceutical business are affected by the digital supply chain.

Keywords: Digital supply chain; JD Logistics; Smart logistics systems; Digital technologies; Post-pandemic; Industry 4.0

1 Introduction

1.1 Background of the Study

The unexpected and rare pandemic outbreak of COVID-19 in early 2020 had a ripple effect on the global economy and severely disrupted global supply chains (Queiroz et al., 2020; Verma & Gustafsson, 2020). With repeated outbreaks, the COVID-19 crisis has become the biggest threat to global stability. As part of efforts to prevent the spread of the virus, borders have been closed, and social distance measures have been taken, but at the same time, global supply chains have been

severely disrupted, crippling world trade. The supply of products has been severely impacted. The effect of COVID on the production links of the worldwide supply chain is profound, especially the damage to raw materials. The shortage and deployment difficulties of critical materials will make it impossible for enterprises to carry out standard procurement and production. Sherman (2020) reported that as of February 21, 2020, 94% of Fortune 1000 companies experienced supply chain disruptions due to COVID-19. Massive layoffs and closings occurred in the weeks following the crisis, according to a survey of small businesses completed on April 4, 2020. (Bartik et al., 2020). Although the research on operations management has extensively researched supply chain management during emergencies, this catastrophe—one that affects nearly all industries across all nations—has not happened recently (Shen & Sun, 2021). Although some enterprises resume working smoothly, they are also faced with trans-regional logistics difficulties and other problems, which will inevitably have a profound impact on the regular supply of products. Supply chains are being made more resilient, collaborative, and networked in the wake of the COVID-19 pandemic (Harapko, 2021).

The COVID—19 pandemic has occurred at a time when the supply chain is undergoing a transition to Industry 4.0 (Frederico, 2021). This pandemic emphasizes changing traditional supply chain models, structured consumption models, and market digitization (Kilpatrick & Barter, 2020; Kim, 2020). A poll of supply chain executives revealed that 64 percent believe the epidemic will hasten the digital revolution (Harapko, 2021). Due to technological advances, supply chain design and operations have evolved into a data-driven, reconfigurable, and viable network approach (Moghaddam, 2017). Agrawal, Dutta, Kelly, and Millan (2021) have noted that Industry 4.0 technology has played an essential role in many companies' pandemic responses. Advanced technologies have dramatically transformed the current period, and digitalization can create new chances for businesses by enhancing the entire value chain (Kilimis, 2019). Still, the crisis has put further pressure on the future of digital operations. One of the key outcomes of the most advanced digital transformation is the visibility and transparency of the end-to-end supply chain established in leading technology companies (Dolgui and Ivanov, 2022).

1.2 Purpose of the Study

A substantial gap might be verified regarding the studies on the pharmaceutical supply chain, Industry 4.0, and COVID-19. Implementing disruptive technologies is critical to achieving faster and more resilient supply chains (Frederico, 2021). As disruptive technologies play an increasing role, understanding organizational performance in new decision settings is a crucial research area. However, findings also show that using technologies like RFID or AGVs includes technological and managerial challenges that call for project management, practical training session, and senior management engagement (Baker and Halim, 2007; Papadopoulos et al.,

2011). Further research is needed to consolidate the emerging digital supply chain field's theoretical foundation (Ivanov and Dolgui, 2020). A new survey from McKinsey (Agrawal, Dutta, Kelly, and Millán, 2021) suggests that companies that had already implemented digital technologies have fared better during the pandemic. At the same time, few cases are studying the pharmaceutical supply chain. Studying the numerous causes of uncertainty in this situation is essential, as is figuring out how businesses should react in such a continually changing environment (Cohen & Lee, 2020). Companies are under increasing pressure to discover innovative methods to generate significantly and provide it to their consumers in the world of global competition today (Alesiuniene et al., 2021). It is also simple to think that the pharmaceutical supply chain may be falling behind in adopting digital technologies due in part to the challenge of integrating strategies that have been successfully used in other industries (Beaulieu et al., 2020; Su et al., 2011). In pandemic conditions like COVID-19, which we explore next, these peculiar problems with pharmaceutical supply networks are amplified. Therefore, studying the impact of the digital supply chain on pharmaceutical logistics can help more companies reduce the risks in the trend of the normalized pandemic era.

This study differs from previous ones in the following aspects. First, our analysis offers pertinent insights into how businesses should respond to long-term crises by outlining the unique features of JD Logistics' pharmaceutical logistics and its operational systems, strategies, and performance throughout the pandemic. In addition, different from other studies based on the global epidemic, this study will pay more attention to the background of China's standard epidemic prevention policies and the measures enterprises can take when the outbreak comes.

Given the importance of digital transformation, the research questions are as follows:

RQ1: How has the digital supply chain affected pharmaceutical logistics?

RQ2: Which digital technologies are primarily used in the pharmaceutical industry?

RQ3: How should companies address long-term disruptions?

This study aimed to identify future research topics related to the impact of digital supply chains on medical logistics management and performance. The remainder of this research is organized as follows. In Section 2, we reviewed the related literature, including digital supply chain, pharmaceutical logistics, and the impact of COVID-19 on the behaviors of both companies and customers. In Section 3, we introduced standard digital technologies using an umbrella review and the formation of JD Logistics with details about information systems using the case study method. Before we discuss the practical strategies companies can take in the future, in Section 4, we analyzed the issues we found based on the systematic review of previous studies and the challenges that JD Logistics is facing. Finally, the main conclusion and recommendations are discussed and summarized in Section 5.

The analysis encompasses practical insights into the digital supply chain and its implementation in the post-pandemic era.

2 Literature Review

2.1 Industry 4.0

The digitization needed by Industry 4.0 has captured the attention of corporate executives and policymakers across the nation since the term "Industry 4.0" was first popularized in 2011. (Ghobakhloo, 2018; Nascimento et al., 2019). Industry 4.0 is the transformation of manufacturing through the incorporation of new technologies such as artificial intelligence, cloud computing (Adel, 2022), analytics, the Internet of Things (IoT) (Ageron et al., 2020), and machine learning (Shen & Sun, 2021) into production facilities and whole operations (What is Industry 4.0 and how does it work?). It was previously thought that Industry 4.0 would be the digital era, but this idea has evolved over the last few years (Xu et al., 2018). Academic, governmental, and commercial partners frequently describe Industry 4.0 as the digitalization and smartening of manufacturing facilities (Kang et al., 2016), production lines, and value chain participants (Liao et al., 2017; Qu et al., 2019). The development of digital technology has ushered in a new productive paradigm (Ehie and Ferreira, 2019). The manufacturing and supply of goods and services may be fueled by merging documentation from many sources and places, thanks to digital technology (Mussomeli et al., 2018). In the Industry 4.0 world, cloud computing systems, advanced robots, and intelligent technologies (Adel, 2022) engage with each other and the ecosystem to share information and eventually decide with hardly any human involvement (Gilchrist, 2016). Industry 4.0 aims to overcome the difficulties of escalating production complexity brought on by elements including escalating inter-firm competition, a range of products, and satisfying the individualized wants of clients (Brecher, Muller, Dassen, and Storms, 2021). By guaranteeing real-time visibility of manufacturing assets through analysis of production operations data to produce better value for businesses, Industry 4.0 delivers unprecedented visibility, and insight from previously isolated information (What is Industry 4.0 and how does it work?). Advancement in SCM is a crucial component for firms to obtain new prospects and sustain their competitiveness in today's business circumstances (Kunrath et al., 2022). Those technologies invented through Industry 4.0 might be used to enhance the historical advantages of supply chain management, such as highly individualized manufacturing and real-time coordination of internal and external data flows (Buyuko¨zkan and Go¨cer, 2018; Zangiacomi et al., 2020).

2.2 The Supply Chain and Digitalization

Supply chains should be viewed as having a close relationship to business operations where inputs are transformed into outputs of positive magnitude (Tsipoulanidis & Nanos, 2022). Studies from Christopher (1999) mentioned that a supply chain is a group of entities that organizes purchasing, manufacturing, and distribution operations from gathering resources down to delivering goods or services to add value for the ultimate consumer. SCM is associated with optimizing the supplier network and including suppliers in the product design and manufacturing processes, according to the standpoint of procurement and supply management (Lamming, 1993; Krause, 2007). Supply chain executives must contend with ever-changing market situations, emerging global marketplaces, and highly competitive conditions as global markets develop (Mehra & Agrawal, 2003; Mehra & Inman, 2004). Many supply chain integration solutions have been proposed since the early 1970s, including enterprise resource planning (ERP) (Beaulieu & Bentahar, 2021), distribution resource planning (DRP) (Ho, 1992), and electronic data exchange (EDI) (Poirier and Reiter, 1996; Bentahar et al., 2016).

The digital supply chain refers to a variety of advanced digital technology (What is a digital supply chain? — reciprocity, 2022; Beaulieu et al., 2020), including long-standing ones like EDI and electronic lists as well as more modern examples like virtualization, the Internet of Things, big data analytics (Raghupathi & Raghupathi, 2014), and blockchain (Chang et al., 2019), and artificial intelligence (Dossou et al., 2021; Ehie and Ferreira, 2019). Innovations in technological tools provide the ground for the digital revolution (Queiroz et al., 2019; Wang and Wang, 2020). For example, due to the utilization of cloud computing, the business has seen a lot of good transformation (Gupta et al., 2022). Because there are cloud options available and there is much competition, the expense is also reasonable. As a result, it is simpler and less expensive (Nagarajan & Minu, 2018) than traditional data-storing techniques (Gupta et al., 2022). The government and businesses will prioritize this since logistics companies with solid innovation in supply chains have shown proficiency in quick delivery and reaction during the epidemic (Liu et al., 2022). Digital supply chains help companies make real-time predictions and suggested actions by integrating internal systems and data with external information (What is a digital supply chain? — reciprocity, 2022). The outbreak of COVID-19 has made it difficult for traditional supply chains to meet the needs of merchants and customers. The digital supply chain realizes end-to-end digitization from companies to market, a new trend in industry 4.0 development.

2.3 Pharmaceutical Industry and Logistics

The complex procedures, activities, and businesses engaged in creating, producing, and distributing pharmaceuticals are referred to as the pharmaceutical industry (Shah, 2004). High R&D expenditures, stringent quality requirements, prolonged manufacturing durations, high recycle ratios, and shortened product cycles are its

defining characteristics. All these factors can boost sales margins along the pharmaceutical supply chain (A. Narayana et al., 2014). To generate long-term value for investors, Beaulieu et al. (2020) define the management of the supply chain in the pharmaceutical sector as the strategy implementation and digital innovation of the entire supply chain of volumes, together with patients, materials, cosmetic and pharmaceutical materials, laundry products, food service, and recycling. Many factors, including stakeholders' attitudes, will affect providers. Due to the distinctive nature of its goods and the complexity of its market interests, the pharmaceutical business has become one of the most dynamic and challenging industries (Tripathi, Talukder, and Rangarajan, 2021). Also, logistics for the pharmaceutical industry has a different standard compared to other products. It has a set of joint procurement but needs to maintain the quality of medicine during transportation (Gizaw, Bogale, and Gudeta, 2021).

There are several ways to interpret the word "logistics." Logistics is the foundation of any manufacturing or marketing business (Lavassani et al., 2008). How the items are supplied to the final consumer affects the corporate's quality (Alesiuniene et al., 2021). Merchandise and resource movement from the producer or supplier to their ultimate consumers and the flow of items from the input materials stage down to the end-user are all involved in the entire value chain (Alesiuniene et al., 2021; Bertodo, 2002). Many seriously affected logistics businesses have become counterproductive and have been combined or had their integrated companies because of the stagnated market and other effects brought on by the pandemic (Liu et al., 2022). Digitization of logistics is very feasible, especially in emerging countries like India (Burroughs & Burroughs, 2020); this sector depends heavily on traditional procedures, which results in resource and time waste and, ultimately, dissatisfied consumers (Gupta et al., 2022). Numerous scholars have used numerical simulations to analyze the supply chain of pharmaceuticals from an operational research paradigm (Feibert et al., 2017). For instance, to enhance batch sizes and timeliness (Dobson, Tilson, & Tilson, 2015), to decrease quality control and quality waste (Tilson, Dobson, Haas, & Tilson, 2014), and to manage the supply chain's complexity because of the market for health products is unexpected. Dimensions must be considered (Jurado et al., 2016).

2.4 The impact of COVID-19 on Customers and Organizational Behavior

The supply chain breakdown and the epidemic's spread among the populace occur simultaneously (Ivanov, 2020). People play crucial roles in the supply chain as employees and buyers of goods (Hald & Coslugeanu, 2021). The outbreak and related measures have profoundly changed customers' behavior (Sheth, 2020). Since the COVID-19 pandemic, people have opted to buy needs via e-commerce platforms to minimize personal interaction (Liu et al., 2022). Consumer expenditure in Denmark decreased by 27% in the seven weeks after the lockdowns, according

to Andersen et al. (2020). There are new expectations because of this unique situation. For instance, the request for shipping and delivery services has significantly expanded because of extensive social distancing policies (Gray, 2020).

For many pharmaceutical enterprises, the traditional pharmaceutical production and marketing chain has many levels, difficult quality control, and a complex interest chain, resulting in the high cost and low timeliness of medicine in the circulation link. With the deepening of its layout in the pharmaceutical field, JD Logistics is becoming increasingly popular in the traditional medicine industry with its solid pharmaceutical business supply chain capability. According to JD's management, the company has undergone organizational and technological reform to establish effective connections with other businesses, which promotes more excellent order to achieve business objectives (Liu et al., 2020). As a group of early social logistics enterprises involved in pharmaceutical logistics, JD logistics, through infrastructure layout and integrated supply chain service advantage, strives to build resource network, operation standardization, quality compliance, and process visualization of supply chain services to provide the most value in pharmaceutical circulation field of supply chain solutions.

2.5 Total Quality Management

The goal of total quality management (TQM) (Feibert et al., 2017), which focuses on constant improvement, is to continuously improve people, communities, and organizations (Kanji & Asher, 1993; Miller, 1995). Although supply chain management (SCM) ideas have received much attention lately, there are frequently limited views between them and the viewpoint of quality management (Kushuwaha & Barman, 2010). However, over the past ten years, businesses have realized that they must not only continuously enhance their products' quality and cater to the wants of their local clients but also compete effectively in rapidly evolving international marketplaces (Kushuwaha & Barman, 2010). The groundbreaking method of total quality management (TQM) is for good operation (AHIRE et al., 2009). Researchers consider TQM a management system (Keng-Boon, 2009) made up of principles, practices, and equipment that attempts to improve the customer experience while using fewer expenses (Klefsjö et al., 2001). Most explanations of TQM begin with ideals like putting the customer first, putting the process first, basing choices on facts, letting everyone be committed, improving continually, and leadership commitment (Ahmadi & Helms, 1995). These principles help define leadership style. Effective TQM adoption might result in several direct and indirect advantages, including optimized staff motivation, a more robust market landscape, enhanced efficiency, and better cost management (Chen et al., 2004). The TQM methodologies and tools that Chen et al. (2004) used to implement TQM in a medical and pharmaceutical logistics (Marinkovic et al., 2016) company are discussed in this case study. It also examines the sales department's merging and development during the execution phase in response to stating the significance of

hiring quality personnel (Chen et al., 2004). Professionals must have the techniques to work on the procedure and monitor the program's performance and the current accomplishment level effectively and efficiently (Kanji & Asher, 1996).

2.6 Theoretical Framework

Supply chain operations reference model (SCOR)

The Supply Chain Council developed the SCOR framework to help simplify the language used to describe Supply Chain management by dividing it into four processes: planning, sourcing, making and delivering (Prakash and Sandeep, 2013). The SCOR model is a critical framework that includes supply chain management techniques, business process reengineering, and a supply chain measurement instrument (Ntabe et al., 2015). The technology environment has changed fast in recent years, but the most famous models measure single metrics by examining the entire supply chain (Cetinkaya et al., 2011). By connecting corporate operations to a cohesive structure, SCOR, according to Haider and Mohailan (2020), offers a distinctive framework for comprehending supply chain models and enhances the efficacy of supply chain management and related supply chain improvement initiatives. This model is divided into two parts. The first section oversees analyzing supply chain operations using models and schematics, and the second section produces critical metrics for these processes (Lepori and Bollecker, 2018). Utilizing the SCOR model's assessment methods enables firms to implement management practices that guarantee customer happiness, boost delivery flexibility, improve product dependability, and cut costs (Minculete and Olar, 2018). SCOR approves the building block approach and provides full traceability (Saleheen, Habib, and Hanafi, 2018). SCOR outlines program types and arranges them to meet the requirements of the supply chain.

3 Method

Researchers frequently employ the systematic review, which incorporates a repeatable scientific procedure (Tranfield et al., 2003). However, in our study, we decided to undertake an umbrella review to integrate universal and particular implications thoroughly. At the same time, we used a qualitative case study method in line with previous latest studies, considering platform building has often been motivated by the marketplace and experience rather than theories. Case study research is regarded as a reliable way to find contextual information that is practically applicable (Wu and Choi, 2005). Given that this project is exploratory, case study research gave us more flexibility to adjust to the conditions and language utilized in other businesses (Yin, 2009). To discover its broad characteristics, we want to explain the realistic environment of the digital supply chain paradigm in pharmaceutical logistics through the case of companies in this part. Secondary data,

in particular the firms' websites, was used to gather the information needed for the leveraging.

3.1 Identification of a Literature Review

Periodic reviews of the literature on the pharmaceutical supply chain have yielded a lot. Utilizing this information will speed up the process of finding digitalization technologies that might be used in the supply chain. Instead of doing a brand-new comprehensive literature study, we draw on prior observations. We used the following keywords to find publications in this field of study: digitalization, supply chain, and pharmaceutical. We investigated through the Web of Science, one of the unrivaled breadths of world-class research literature linked to a rigorously selected core of journals to ensure the quality of our literature reviews.

The search for the articles was based on the following keywords: medical, pharmaceutical, and digital supply chain. We also excluded several articles that focus on pharmaceutical materials, chemistry, sustainable medicines, planning production, 3D printing, and reports that are unrelated to us. After reviewing and analyzing all the studies we found, 24 articles were reserved to illustrate our thinking.

It is worth noting that these articles are all related to supply chain management, although some publications mainly introduce other concepts such as coping strategies, system design, and lean principles. These articles may be limited in their design development, but that does not mean they are irrelevant to supply chains.

3.2 Case Study for JD Logistics

JD Logistics is an outstanding supply chain solutions and logistics services provider in China (Company profile. JD Logistics). According to its official website (Company profile. JD Logistics, n.d.), with more than 190,000 commercial clients and services for fast-moving consumer goods, clothing, furniture, home appliances, 3C, automobiles, and fresh food, JD Logistics climbed to the position of largest effective supply chain logistics network in China by 2020. Online e-commerce platforms now work more closely with a range of sectors because of the pandemic, and they serve as a crucial observation point for how the epidemic is affecting the supply chain (Shen and Sun, 2021). JD Group still achieved good performance during the outbreak with the advantage of self-established logistics.

3.2.1 Formation of JD Logistics Service Quality

China was late in developing its logistics industry. Despite recent strong growth, there is still tremendous opportunity for service performance advancement and a significant disparity compared to wealthy nations (Yang, 2021). One of the obstacles preventing China's logistics from developing is the caliber of the services

provided in the field of logistics. For JD.com, there are two main distribution modes: self-run logistics and cooperation with third-party logistics. JD.com ran "23 Asia No.1" logistics parks, the most significant and innovative distribution units in Asia (Galea-Pace, 2020). They are the most extensive and automated fulfillment facilities of any e-commerce firm in the world, and the company has a network of 600 warehouses totaling 15 million square meters (Galea-Pace, 2020). Also, JD Logistics announced its partnership with third-party logistics companies ahead of the Double 11 online shopping festival in 2019. Since JD Logistics is attempting to diversify and now only takes orders placed on JD.com platforms, the decision could assist it in generating additional charges from outside sources (Li & Yuan, 2019). It will also make it possible for JD Logistics, which had a long history of losses until turning a profit this year, to fight effectively with other logistics businesses (Li & Yuan, 2019). During the epidemic, various delivery endpoint types were employed. JD.com debuted its first "mini shipping station" last year (Shen & Sun, 2021). Only a small number of items were stored and transported at this station, and the shipping and pickup services required strict personal protection equipment (Shen & Sun, 2021). Throughout the services, remote tracking was utilized. According to research by Shen & Sun (2021), the contactless delivery method performed effectively. Despite the high number of orders placed during the pandemic, JD.com's adaptable offerings allowed for a lower-than-usual percentage of consumer complaints (Shen & Sun, 2021).

3.2.2 Formation of JD pharmaceutical business

Based on a report made by one of JD's employees, Yang (2021), pharmaceutical e-commerce can serve consumers anytime and anywhere they require medicine, thanks to the integration of online and offline activities and the availability of last-mile shipping solutions on the market. According to Yang (2021), JD.com has seen that its growth in a variety of areas, such as full-category expansion, omnichannel operations, medical services, and more, is a proactive reaction to the shifting demands of consumers in China. As Zhang (2022) mentioned, with "more than 15% of China's pharmaceutical retail sector", JD has established itself as the country's top pharmacy retailer. To create the largest and most comprehensive e-commerce environment in the sector, JD's pharmaceutical business has further expanded to include "B2C (Business-to-Consumer), B2B (Business-to-Business), and O2O (Online-to-Offline) transactions" (Zhang, 2022). JD is also simultaneously utilizing its statewide distribution network, which reaches 99% of China's population, to ensure medicine delivery to those residing in the country's outlying regions (Zhang, 2022). As a critical component of JD Health's B2C business, JD Pharmacy has grown to reach China's leading pharmaceutical e-commerce platform, with a growth rate that is four times faster than China's industry average (Zhang, 2022). Zhang (2022) figures out that JD launched its B2B business in addition to its B2C operations by creating a network to purchase pharmaceuticals named "JD Pharmaceutical Procurement" to enhance the effectiveness of existing methods for data distribution and raise informational transparency. In addition, Zhang (2022)

said JD also created a multichannel medication delivery solution in collaboration with offline shops to increase the commercial gain for clinics while offering patients quick access to medications. Customers may use the platform to submit purchases with neighboring clinics based on geographical locations, and the business guarantees that the medicines will be delivered within 30 minutes (Zhang, 2022).

3.2.3 Smart logistics platforms and technical support of JD Logistics

Supply chains grow more complicated and customers more demanding as e-commerce becomes more widespread. As a result, an increasing number of businesses, like JD.com, are looking to technology to aid in the more effective management of their supply chains. Through the intelligent platform, JD Logistics gives demand-side and supply-side sustainability parties more influence (Chan et al., 2018). JD.com has constantly invested in digitization to reduce costs and enhance service quality. To develop a distinctive core competency for JD Group, the Qinglong software platform of JD Logistics depends on a quick and effective logistics distribution network (Li & Zhong, 2021). Each JD Group user's transaction processing procedure relies on a collection of sophisticated logistical systems that JD refers to as "Qinglong" (Li & Zhong, 2021). To accomplish feedback controller monitoring, JD Logistics has a team linked with clients and vendors at the institutional level (Liu et al., 2020). JD.com successfully manages logistical tasks, including warehousing, shipping, distribution, and sorting, with the help of this collection of systems.

Quality control platform

JD.com has exacting standards for product quality. The quality management system monitors and gathers on-site aberrant data, such as transportation inefficiencies during the execution of the company process, to prevent harm brought on by shipping (Li & Zhong, 2021). Its self-developed "Commodity quality Management system" can use many transactions and review data, perform a risk assessment and screening of the goods on sale, and proactively find potential quality risks. JD’s quality management system will be different attributes of the quality problem stratification, and then according to the severity of the problem classification; At the same time, the system monitors the whole process of goods, records the information of goods at each node, and can be accountable to suppliers and even producers. The quality control system guarantees prompt detection of aberrant deliveries while providing excellent assurance to lower shipping costs (Li & Zhong, 2021).

Waybill and routing system

The routing system of JD.com can provide an evaluation standard for the operation efficiency of the logistics network based on the practical operation of the logistics network. At the same time, it can be collected by the downstream-specific data processing system and finally aggregated into logistics information that can be

queried and counted for logistics customer service, front-line personnel, and network planning. According to Li & Zhong (2021), the waybill system also offers assistive technologies like the resolution platform and the ability to contact it for external inquiry features like progress and payment options.

Monitor and JIT system

In the warehousing and production process, JD.com implements the JIT production mode. All users' orders will be released at the appropriate time, packed, sorted, and delivered, and the goods will be delivered according to the promised time to customers. JIT systems divide orders into waves to affect warehouse production and distribution. JIT orders have a concept of priority. The higher the priority, the earlier the warehouse production and delivery. The Qinglong system provides a hierarchical installation strategy, thus opening the option for worldwide monitoring to assist leaders and managers in the final choice (Li & Zhong, 2021). Managers and supervisors may keep track of each area's operational state in real-time and make prompt general preparations based on how efficiently each connection works (Li & Zhong, 2021).

4 Results

4.1 Technology Trend of Industry 4.0 in the Pharmaceutical Industry

The ability to reduce production costs, enhance product quality while boosting operating profits via growing industry shares, planning a project that better serve customers, and gain a tactical advantage that enhances all company's operations are functionality that digitalization enhances (Ehie & Ferreira, 2019). The technology trends in the pharmaceutical industry are identified in blockchain and the internet of things (IoT), according to the literature reviews in the methodology. Although the publications from the existing literature will serve as the foundation of our discussion, we will also reference additional sources that support the proposed effort.

Blockchain is an innovation with many uses, including cryptocurrencies, financial institutions, risk management, and social and government assistance (Bamakan et al., 2020). It offers a couple of different ledgers that are digitally accessible to every network member, allowing them to monitor and confirm transaction-related data, resulting in most sectors being interested in it (Abbas et al., 2020). The preceding block's hash value is included in each new block. As a result, all blocks are connected by their codes. Consequently, whenever a block's information is changed, its hash code alters, and all subsequent blocks must be modified (Bamakan et al.,

2020). It is the ideal choice for managing and safeguarding the pharmaceutical medication supply chain process.

The Internet of Things is particularly effective in detecting heat in real-time in the pharmaceutical and biotechnology sectors (Bamakan et al., 2020). It provides the opportunity to remain updated with rules, lower operational waste costs through exchanges, and locate items promptly at any phase (Balachandar and Chinnaiyan 2020). All items will have recognition, sensing, connecting, and computational power thanks to the IoT ecosystem, enabling them to communicate and exchange data with one another and create cutting-edge services online (Dossou et al., 2021). On the other hand, the organizational system will have to handle a vast number of data produced by these tracking apps, which might result in additional expenses for buying and subscribing to local databases.

Table 2

Research technologies resulting from the list of publications on pharmaceutical supply chain

Authors	**Blockchain**	**Internet of Things (IoT)**
Argiyantari et al. (2020)		
Saeed et al. (2022)		
Bamakan et al. (2021)	x	
Marnnolejo-Saucedo & JA (2020)		
Kumar et al. (2022)		
Munir et al. (2022)		
Musamih et al. (2021)	x	
Ertz et al. (2022)		
Harrington et al. (2017)		
Raijada et al. (2021)		
Sarkis et al. (2021)		x
Singh et al. (2020)		
Erokhin et al. (2020)	x	x
Sigley & Powell (2022)	x	
Park & KM (2021)	x	
Parvathi et al. (2022)		
Velmovitsky et al. (2021)	x	
Mackey & Cuomo (2020)	x	
Jiao et al. (2022)	x	
Alkhoori et al. (2021)		x

Tan et al. (2020)	x	
Virgolici et al. (2022)	x	

4.2 Identified issues from previous studies

The difficulties that pharmaceutical logistics will face over the coming years have been emphasized. The papers suggested for this special issue add to the body of knowledge on medical logistics. A greater understanding of logistics concerns on SCM approaches, including upgrading process, quality control, distribution network design, and performance in this context, is provided through global case studies.

Martin Beaulieu, Omar Bentahar, and Smail Benzidia's *"The Evolution of Healthcare Logistics: The Canadian Experience"* offer the chance to examine the history of pharmaceutical logistics and try to identify the crucial developmental trends to the long-term viability of healthcare delivery systems. Researchers interviewed top executives of the advanced infrastructure departments of several institutions to emphasize the role of logistics in medical groups before and after transformation, with more than ten interviews (Beaulieu et al., 2020). When introducing various information systems, the respondents emphasized the difficulty of harmonizing the different logistical procedures left over from the previous architecture (Beaulieu et al., 2020). The research also made clear that to enhance practices in data processing and transportation performance assessment, it would be necessary to integrate emerging innovations like big data analytics and artificial intelligence as well as more customer and coordinated information management systems (Beaulieu et al., 2020).

The difficulty facing medical systems worldwide is rising expenditures brought on by an aging population and more advanced therapies (OECD, 2015). Patients also call for affordable, high-quality healthcare (Feibert et al., 2017). In their article *"Benchmarking healthcare logistics processes a comparative case study of Danish and US hospitals,"* **Diana Cordes Feibert, Bjørn Andersen & Peter Jacobsen** listed several considerations pertinent for developing and measuring processes available to executives in medical logistics as part of the study's contribution to the scant research on assessing in medical logistics. The comparative case study explores various case studies at five Danish hospitals and two case studies at a US hospital. It was determined that the "output quality, consistency, employee engagement, probability of errors, and security of supply" were the five most crucial decision factors.

Vimal Kumar, Kyaw Zay Ya, and Kuei-Kuei Lai, in their paper *"Mapping the key challenges and managing the opportunities in supply chain distribution during COVID-19: a case of Myanmar pharmaceutical company,"* recognizes the significant supply chain issues and oversee the possibilities that this pharmaceutical firm implemented. The study used a case study plus interviews with

managers to create a thorough linkage to evaluate subordinates to reduce uncertainty. The upper main issues have been listed as being the influence of legal factors, postponement in the migration of data, poor online service, limited awareness of how to use the digital channel, poor knowledge exchange on the website by staff members, and communication processes from higher leadership to tactical level," in both.

4.3 Challenges for JD Logistics

As an e-commerce giant, JD's most outstanding ability is its logistics capability. Its entry into the Internet medical field will likely start from pharmaceutical e-commerce. However, the effectiveness of drugs and devices is higher than the current logistics system of JD, and there are still many problems and challenges to be solved.

First, the uncertainty of demand planning. According to the 2021 annual report, JD Logistics was listed as a critical enterprise of COVID-19 vaccine transportation by the Ministry of Transport in 2021, responsible for the vaccine distribution business in Beijing, and gradually carried out several vaccine transportation cooperation projects. In addition, JD Logistics has also become the general warehouse and logistics service provider of athletes' food materials for international sports events, providing integrated logistics services such as procurement, storage, transit, and cold chain logistics distribution.

Second, the hardware and software facilities are not complete. According to the interim report for JD Logistics, until June 30, 2022, JD Logistics operates more than 30 dedicated medicines and medical device warehouses with a functional area of more than 200,000 square meters. In addition to the shortage of infrastructures such as transportation and storage, the lack of information technology and management level is also an important reason for the backward development of logistics hardware. Third-party logistics also needs to actively carry out work and cultivate talents to develop and strengthen themselves; Unfortunately, JD Logistics has significant investment and advanced infrastructure but has not reached a certain level in management and other aspects.

Lastly, industry competition increases risks. According to the company's prospectus, by the first half of 2020, JD Health's self-operated business pharmaceutical sales revenue accounted for 29 percent, and non-medical revenue accounted for 71 percent. The upward growth rate of JD health medicine revenue is due to prescription outflow, procurement with quantity, category adjustment dosage forms that are not convenient for online sales are put into e-commerce, C2M OEM products are expected to be online in the future as more basic medicines join the collective purchase, and prescription outflow accelerates. There is still room for improvement in medicine growth. JD Logistics' main competitors in the pharmaceutical e-commerce field include, but are not limited to, retail

pharmaceutical companies and companies providing online medical and health services. These companies also have advantages in technology, research and development, marketing, distribution, retail, and other resources. They may have a long history of operation, a more extensive user base, or broader and deeper market coverage. JDL's competitors may respond more quickly and effectively to new opportunities, technologies, standards, or user needs and be able to cope with or withstand significant regulatory changes and industry evolution.

5 Conclusions

5.1 Conclusion

Our analysis also creates new avenues for investigating pharmaceutical logistics and advancement tactics. First, there are not many literature reviews on the pharmaceutical logistics supply chain since the epidemic, and there are few studies on China's unique conditions. Through analyzing the current literature review and the strategies of the leading logistics company JD Logistics, our research innovatively puts forward the technology that pharmaceutical logistics can invest heavily in the future. In addition, based on the original big data technology, we proposed a more meaningful and influential blockchain concept.

In the battle against COVID, the critical role of emergency logistics, medical logistics, and so on has become increasingly prominent. It can be expected that strengthening logistics infrastructure construction will become an important direction in the future. The first is the research and application of new technologies, especially blockchain, big data, cloud computing, and other technologies. Blockchain technology can ensure that the transaction data in the supply chain is not tampered with, effectively solving the security problem of credit data, especially for the entire transaction process can be effectively recorded and can reduce medical risks. With blockchain, customer records may remain secure and private while receiving high-quality care at a relatively affordable price (Bamakan, et al., 2020). Big data and cloud computing can carry out a risk assessment, risk warning, risk pricing, quantification, and visualization for financing enterprises. The vendor can best explain the client's needs and tailor the deployed platform for specific workflows owing to big data tools and methodologies (Morawiec & Soltysik-Piorunkiewicz, 2022). The second is the innovation of the medicine supply chain mode. In the process of pharmaceutical circulation, drug quality, drug safety, and drug traceability are all essential areas closely related to the innovation of drug circulation supply chain mode and government supervision. As the country pushes forward the separation of pharmaceutical industries and vigorously builds a public health system, the supply chain finance platform built by medical institutions is also gradually landing.

5.2 Implications

5.2.1 Theoretical Implications

This paper makes a theoretical contribution to research on pharmaceutical logistics. Firstly, there is a trend of intellectual development in pharmaceutical logistics. Informatization is the critical factor for the successful expansion and reduction of management costs of pharmaceutical circulation enterprises and the most basic support for better and faster response to customers. To better reduce the pharmaceutical logistics distribution cost, we must rely on applying the new technology of the Internet. Warehouse management, transportation management, temperature control supervision, positioning management, and other processes need to use more advanced information technology to help fresh e-commerce to achieve safety traceability, quality can be monitored, and order information can be tracked. Intelligent pharmaceutical logistics should be realized through the application of big data, the Internet of things, and other technologies, which will significantly improve the efficiency of logistics distribution and better manage and control the whole logistics distribution.

Secondly, the pharmaceutical logistics market maintains rapid development, and evidence of the pharmaceutical market space is enormous. It also reflects the characteristics of medicine as a sunrise industry, and the current market pharmaceutical logistics mixed, market, brand, etc., have not yet integrated. The pharmaceutical logistics field is mainly led and guided by policies to guide the development of the industry. With the implementation of various approaches, the pharmaceutical circulation links are compressed, and the gross profit is gradually reduced. The leading enterprises have also implemented lean logistics management to reduce costs, increase efficiency, and improve competitiveness. It is necessary to work for the sustainable development of each enterprise to build an exemplary medical logistics distribution system.

5.2.2 Managerial Implications

The findings of this research provide managerial implications for companies that are doing pharmaceutical logistics business. The sudden outbreak of COVID-19 in early 2020 deepened the public's understanding of the importance of developing pharmaceutical logistics. Upgrading of information technology, emergency management system, supply chain innovation, and Internet Plus has become the focus of national construction and development. Against everyday epidemic prevention and control, the informatization construction of the pharmaceutical logistics industry makes it possible to reduce costs and increase logistics efficiency, drug traceability, pharmaceutical e-commerce, and other model innovations. The informatization of pharmaceutical logistics is the main direction of the development of pharmaceutical logistics in the future.

The application of information technology in pharmaceutical logistics is mainly reflected in the realization of multi-code coexistence, which can be checked in place, can be traced in an area, the establishment of a medicine information traceability system, in addition to the uncrewed vehicle, unmanned warehouse, and other advanced technologies, to create a standardized, standardized, technical smart pharmaceutical logistics.

In the future, from the perspective of the Chinese environment, the internet plus is still the development direction of the industry. The strategy intends to incorporate digital technology to advance the financial sector, enhance people's quality of life, and even change governmental operations (Wang et al., 2016). According to Wang et al. (2016), Internet Plus will significantly advance over the coming years and transform China's industrialization and entrepreneurial framework. Although the policies of China's pharmaceutical e-commerce industry may be repeated, the general direction is relatively specific: The Internet Plus is the opportunity to develop the pharmaceutical circulation industry. The epidemic has brought about changes in new business models in the distribution field. Future medical e-commerce should include online transactions among enterprises in the medical circulation link and the retail drugs and the online retail of pharmaceutical circulation enterprises to consumers. Therefore, a perfect logistics distribution system is indispensable.

5.3 Limitations and Future Research

This study has certain limitations, which present chances for further research. Even though the analysis was carried out with meticulous integrity, another research has to be done. Although our research object is JD Logistics, due to the confidentiality of the data, we cannot release its specific data in the field of pharmaceutical logistics. No further evaluation can demonstrate the validity and dependability of the solutions. Thus, recommendations on logistics performance are made solely on archival research.

The corporation should do more studies to confirm the viability of the solutions suggested from the standpoint of logistics management. JD Logistics should put the suggestions into practice for the operators and assess the results to compare them to prior performance. I can state that excellent logistics management may raise process efficiency in the pharmaceutical business while providing the same contribution if total operator quality of services is offered.

Exceptional case management should also be the focus of future studies. The existing system and procedure still don't have a soundtrack and trace feature to identify lost or misplaced products. The time spent on anomalous cases is considered a profitability loss and should be reduced or eliminated.

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