

Implementing Just-In-Time Healthcare Supply Chain Through IoT and Modern Cloud Data Platforms

Mahesh Babu Munjala¹, Chinmay Kulkarni²

¹Sr. Business System Architect

²Data Scientist

Abstract

Healthcare organizations face significant challenges in their supply chain management efficiently. Inefficient healthcare supply chains can lead to stockouts, delays, and ultimately, poorer patient care. This paper proposes a novel approach that integrates Just-in-Time (JIT) principles, Internet of Things (IoT) devices, and cloud data platforms to address these challenges and improve healthcare supply chain efficiency. Major objectives for healthcare supply chain management are to streamline communication, increase real-time monitoring and enhance decision making processes. This research study employed a qualitative approach based primarily on previous research studies. Key findings highlight that the integration of IoT, and cloud technology can result in improved communication, effective decision making, reduced operational costs, and improved responsiveness.

Keywords: Healthcare supply chain, modern cloud data platform, IoT, Just-In-Time

1. Introduction

1.1 Background

Healthcare organizations require an effective, responsive, and robust supply chain due to its complex and critical nature. Traditional supply chain models often lack the ability to meet the dynamic demands of healthcare supplies [1]. The implementation of a Just-In-Time (JIT) approach is hugely successful in the manufacturing sector and has the potential to revolutionize the healthcare supply chain by reducing waste and optimizing resource utilization [2]. Other technologies that have transformative potential to change the supply chain management in healthcare services include the utilization of IoT devices such as RFID tags and sensors [3], in addition to cloud data platforms.

1.2 Statement of the Problem

Current supply chains in the healthcare industry are inefficient and are facing hurdles like wastage, higher costs, and delays. Absence of real-time visibility and outdated inventory management system are the challenges [1][2]. It is important to address these issues in the supply chain of healthcare to ensure timely delivery of medical supplies especially in critical conditions like pandemic or health emergencies.

1.3 Objectives of the Study

The major primary objective of this research study is to examine the feasibility and benefits of implementing the JIT supply chain in the healthcare industry using the IoT devices and modern cloud data

platforms. Other specific goals are to measure cost reduction, improvement in operational excellence and overall responsiveness to healthcare supply chain demands.

1.4 Significance of the Study

This research study is significant for healthcare supply chain optimization and allows access to essential medical supplies without delays. By integrating JIT principles, cloud technologies and IoT devices, the healthcare industry can achieve reduction in costs, preparedness for unforeseen circumstances, and improved patient care.

1.5 Research Questions and Hypotheses

Research under this study is guided by the following research questions:

1. How does the accession of IoT and cloud data technologies into the healthcare supply chains can impact their efficiency and responsiveness?
2. What are the potential savings of cost associated with the adoption of JIT principles into the healthcare industry?
3. Does real-time monitoring and data-driven decision-making process affect the responsiveness of the healthcare supply chain?

2. Literature Review

2.1 Just-In-Time (JIT) in Healthcare Supply Chain

JIT principles have gained popularity in the healthcare sector following successful implementation in the manufacturing sector, as a result of reduced costs and improved efficiency. The emphasis of JIT principles lies in the timely delivery of supplies, in the appropriate quantities and to the correct location. Within the healthcare industry, JIT principles are centered around the optimization of inventory, with the aim of ensuring the availability of medical supplies at the right time, without any surplus stock. Research studies have highlighted that the application of JIT principles can yield cost savings and enhance the responsiveness of healthcare supply chain [4].

2.2 Role of IoT in Healthcare

IoT plays a crucial role in the healthcare industry by providing access to real-time data and information through interconnected devices. In the context of medical supplies, IoT helps the real-time monitoring and tracking of medical inventory and increasing the visibility that leads to timely decisions. IoT devices such as RFID tags and sensors can help to track the expiration dates, usage patterns, and monitor storage conditions that can lead to reduced wastage and prevention of stock outs [5]. Thus, integration of IoT in the healthcare industry can result in less wastage, reduction in costs, enhanced traceability, less errors and increase in healthcare supply chain visibility.

2.3 Integration of Cloud Data Platforms in Supply Chain

Cloud data platforms are necessary in the backdrop of IoT devices. Cloud data platforms in the healthcare industry provide scalability and flexibility in storage and retrieval of large volumes of data produced by the IoT devices. Cloud data platforms offer seamless collaboration among different stakeholders in the healthcare supply chain. Cloud based systems have a centralized data repository for having real-time data that facilitates effective and efficient communication and decision-making processes. Research studies show that the adoption of cloud data platforms can provide agility and strength of supply chains [6][7].

2.4 Previous Studies on JIT, IoT, and Cloud in Healthcare

Several research studies have examined the usability and impacts of IoT, cloud data platforms and JIT principles on healthcare supply chains. Research by Balkhi et al. (2022) shows the benefits of JIT

principles in a hospital setting in reducing excess inventory and associated costs [8]. Another research study by Zhu et al. (2012) highlights the role of IoT devices in improving supply chain visibility and mitigating uncertainties in healthcare logistics [9]. Additionally, Wang et al. (2016) in their investigation emphasized the integration of cloud data platforms with IoT devices for effective healthcare supply chain management [10]. All these research studies suggest that the combination of JIT, IoT, and cloud technologies can develop a more responsive and efficient healthcare supply chain system.

2.5 The Interplay of JIT, IoT, and Cloud Technologies

The integration of IoT, Just-In-Time (JIT), and cloud data technologies with the healthcare supply offers a transformative experience of having a more efficient, responsive, and interconnected ecosystem.

JIT principles, which focuses on the reduction of wastage, timely delivery and reducing inventory, aligns perfectly with the IoT system that facilitates real-time monitoring and tracking of information.

While the continuous flow of data from IoT devices to the cloud data platforms allows the decision makers to take data driven decisions based on most current real-time information. This combination produces an environment that encourages robust, resilient, and responsive supply chain management in the healthcare industry. It allows healthcare organizations to respond swiftly to tackle unforeseen events, calamities, and changes in demand. In conclusion the amalgamation of IoT, cloud platforms and JIT develops a holistic environment for a patient-centric supply chain system.

2.6 Challenges and Future Directions

While the benefits of integration of JIT, cloud platform and IoT are immense, the challenges must also be acknowledged. Patient privacy is a major concern. Data generated by IoT and stored in cloud platforms are huge and of a sensitive nature that needs to be safeguarded by stringent standards and robust safety framework. The second challenge is the upfront costs attached with the implementation of these technologies and some healthcare organizations may not find it feasible to bear such costs. Future research should examine and explore strategies to address these challenges and develop innovative methods to enhance data security and affordability. Simultaneously, the expanding landscape of the healthcare supply chain would necessitate an ongoing exploration of emerging technologies to achieve continuous improvement in integration methodologies. Healthcare supply chains can achieve a state of optimal efficiency and responsiveness by overcoming these challenges and retaining an edge over the budding and innovative technologies. This approach will ultimately benefit the patient's outcomes.

This literature review summarizes transformative potential of IoT, cloud platforms and JIT in healthcare supply chains. Healthcare organizations would need to understand collective and individual potential benefits and challenges related to each technology to develop modern and resilient supply chains in a dynamic, ever-changing healthcare landscape. Ultimately this literature review offers an understanding for the foundational concepts like IoT, JIT principles and cloud platforms for healthcare supply chains. The existing research suggests that integration of IoT, cloud, and JIT technologies can revolutionize the healthcare delivery system by addressing the key challenges like decreasing cost, waste reduction, and improved decision-making process in the healthcare supply chains.

3. Methodology

Methodology of this research study primarily depends upon the extensive review of existing literature to gain understanding and insights about the key technologies, Just-In-Time (JIT) principles, Internet of Things (IoT), and cloud platforms for the integration with healthcare supply chains. Under this research study various relevant studies, articles and scholarly work has been synthesized and analyzed to explore

the individual as well as collective impacts of IoT, JIT and cloud technologies on the healthcare supply chains. Present research initiated with the identification of key databases, including Google Scholar, PubMed, IEEE Xplore, and ScienceDirect, to gather peer-reviewed articles, conference papers, and books. Here the search strategy has involved a combination of several keywords such as "Just-In-Time," "IoT in healthcare," "cloud platforms in supply chain," and related terms. The inclusion criteria were based on a number of conditions. These were set to select publications that focused on the application of JIT, IoT, and cloud technologies specifically within healthcare supply chains, number of citations, and time relevance. To ensure that the selected literature is relevant and reliable, preference was given to recently published studies, especially those within the last decade. It is important as the healthcare sector has been witnessing rapid technological evolution and change.

Then selected literature was arranged thematically to understand individual aspects of JIT, IoT and cloud technologies, including benefits, challenges, applications, and efficiency in their interconnections. This literature review helps to understand the status of each technology along with their future potential and synergies when they are integrated.

The outcome of this methodology is a synthesized and comprehensive literature review that provides a solid foundation for understanding JIT, IoT, and cloud technologies in healthcare supply chains. The insights gained from this literature review will inform the subsequent stages of the research, contributing to the development of a conceptual framework and the identification of gaps that warrant further investigation.

4. Results and Discussion

The results and discussion section represents key findings derived from the literature review on the integration of JIT, IoT and cloud data platforms with the healthcare supply chain system.

4.1 Just-In-Time (JIT) in Healthcare Supply Chain

The research studies express the positive impact of implementing JIT principles in healthcare supply chains. A research study by Burgess et al. (2012) emphasizes that JIT has potential for reduction in operational costs and enhanced responsiveness [4]. The core philosophy of JIT is to deliver the right quality at the right time aligns perfectly with the dynamic demands of the healthcare industry. The application of JIT principles in the healthcare supply chain management can lead to reduced wastage, resources utilization optimization and improved responsiveness and efficiency. This core fundamental of JIT fulfills the broader objective of healthcare organizations and ensures the timely availability of medical resources, particularly in critical situations like medical emergencies.

4.2 Role of IoT in Healthcare

Research studies show that integration of IoT in healthcare supply chain management promotes real-time monitoring, visibility, and data-driven decision-making. IoT devices, such as RFID tags and sensors provide real-time data and information on inventory levels, storage conditions, and usage patterns [3]. This real-time visibility helps the management to prevent stock run-out and reduce the risk of expired or wasted inventory. It also contributes to improved traceability, reduced errors, and enhanced overall visibility.

4.3 Integration of Cloud Data Platforms in Supply Chain

Cloud based data platforms offer scalable and flexible solutions for entertaining the huge amounts of data generated by IoT devices in healthcare supply chains [3][5]. The literature underscores several advantages of cloud-based solutions which includes efficient storage, processing, analysis, and retrieval of real-time

data. Collaboration and seamless communication among different stakeholders became possible with the centralized repository provided by cloud platforms. It helps to make effective and accurate decisions. Cloud integration is critical for healthcare organizations that seek to modernize their supply chain operations and respond effectively to dynamic market demands.

4.4 Previous Studies on JIT, IoT, and Cloud in Healthcare

Past research studies show a strong and collective support for the integration of JIT, IoT, and cloud technologies in healthcare supply chains.

For instance, Inman et al. (2010) and Balkhi et al. (2022) underscore the positive effects of JIT principles in the healthcare supply chains for keeping the inventory updated with removal of excess inventory and reducing the associated carrying costs in a hospital setting [2][8]. Another research study demonstrates the key role of IoT devices in improving supply chain visibility and reducing uncertainties in healthcare logistics [5]. While the study by Wang et al. (2016) emphasized the integration of cloud platforms with IoT for effective healthcare supply chain management. It also highlights the synergy between these technologies.

5. Discussion

The integration of JIT, IoT, and cloud technologies depicts a holistic approach to optimizing supply chains in the healthcare sector. The literature review displays the complementary nature of these technologies where JIT principles complement the real-time monitoring capabilities of IoT devices and cloud-based data platforms. It provides the necessary infrastructure for efficient data storage and processing. The improved responsiveness achieved through JIT principles and real-time visibility offered by IoT devices enabled healthcare organizations to make data-driven informed decisions. The integration of cloud-based data platforms further facilitates collaboration and communication among different stakeholders for removing challenges related to information silos and introducing a more robust and interconnected supply chain system. However, challenges such as data security and upfront implementation costs need to be carefully considered. Thus, future research should focus on exploring strategies to enhance data security in IoT-enabled healthcare supply chains and developing cost-effective approaches for the widespread adoption of these technologies.

In conclusion, the results and discussion highlight the transformative potential of integrating JIT, IoT, and cloud technologies in healthcare supply chains. The literature review provides a comprehensive understanding of the current state of research in each area, forming the basis for future investigations into the practical implementation and impact of these technologies in real-world healthcare scenarios.

6. Conclusion

The integration of JIT principles, IoT and cloud data platforms infrastructure provides a chance to develop a transformative supply chain system in healthcare industry based on efficiency, responsiveness, and accuracy. The literature review offers a comprehensive understanding and valuable insights about the individual technologies and their potential impacts along with collective effects on healthcare supply chains. These insights provide a foundation for understanding the role of JIT, IoT and cloud data platforms in shaping the future of healthcare supply chain management.

Integration of JIT with the Healthcare supply chain system is crucial for the healthcare sector to deliver medical supplies within a timeframe and achieve cost efficiency, operational excellence, reduction in waste and high responsiveness. While IoT devices and their integration allows healthcare supply chains

to become highly visible and traceable on a real-time basis. IoT also helps the decision makers to take data-driven, informed, and accurate decisions on a real-time basis. Monitoring and tracking are also feasible with IoT devices like RFID tags and sensors to read usage patterns, expiration date, usage conditions, inventory levels, and stock conditions. This real time databases monitoring and evaluation empowers organizations to manage their supply chains, prevent stockpile, stockouts and expiration.

While the integration of cloud-based data platforms complements the usage of IoT and JIT to store, process, analyze and retrieve huge amounts of data on scalable and flexible solutions. Such cloud-based data platforms develop a centralized repository for entraining real-time data to foster seamless collaboration and communication among different stakeholders. The outcome is a more robust, agile, and interconnected supply chain in healthcare those are capable of adapting to dynamic market demands and unforeseen medical emergencies. The literature review displays the transformative potential of JIT, IoT, and cloud data technologies in healthcare supply chains along with the challenges such as data security, individual privacy and bearing upfront implementation costs, that must be addressed. Future research should focus on developing those strategies that can enhance data security in IoT-enabled healthcare supply chains and creating cost-effective approaches for widespread adoption.

In conclusion, existing knowledge highlights the importance of embracing innovative technologies to develop more robust, responsive, efficient, and patient-centric healthcare supply chains. The insights gained from this literature review set the foundation for future research and practical implementation. It ultimately contributed to the effective transformation of healthcare supply chain management in an era of technological evolution. This research emphasized further exploration into the practical implementation and impact of JIT, IoT, and cloud technologies in real-world healthcare conditions. The integration of these technologies with the healthcare supply chains holds a promise to play a pivotal role in shaping a more resilient and adaptive healthcare ecosystem as healthcare organizations poised to navigate the complexities of supply chain management.

7. References

1. Lee, H. L., & Padmanabhan, V. (1997). The Bullwhip Effect in Supply Chains. *Sloan Management Review*, 38(3), 93–102.
2. R. A. Inman, R. S. Sale, K. W. Green, and D. Whitten, “Agile manufacturing: Relation to JIT, operational performance and firm performance,” *Journal of Operations Management*, vol. 29, no. 4, pp. 343–355, Jun. 2010, doi: 10.1016/j.jom.2010.06.001.
3. M. Ben-Daya, E. Hassini, and Z. Bahroun, “Internet of things and Supply Chain Management: A literature review,” *International Journal of Production Research*, vol. 57, no. 15–16, pp. 4719–4742, Nov. 2017. doi:10.1080/00207543.2017.1402140
4. N. Burgess and Z. Radnor, “Evaluating Lean in healthcare,” *International Journal of Health Care Quality Assurance*, vol. 26, no. 3. Emerald, pp. 220–235, Mar. 15, 2013. doi: 10.1108/09526861311311418.
5. K. Sallam, M. Mohamed, and A. Wagdy Mohamed, “Internet of Things (IoT) in Supply Chain Management: Challenges, Opportunities, and Best Practices,” *Sustainable Machine Intelligence Journal*, vol. 2. Deepology Lab, Mar. 27, 2023. doi: 10.61185/smij.2023.22103.
6. I. Lee and G. Mangalaraj, “Big Data Analytics in Supply Chain Management: A Systematic Literature Review and Research Directions,” *Big Data and Cognitive Computing*, vol. 6, no. 1, p. 17, Feb. 2022, doi: 10.3390/bdcc6010017.

7. Narayana Challa, "The Crucial Role of Integrations in Data Engineering: A Comprehensive Exploration", *International Journal of Science and Research (IJSR)*, Volume 9 Issue 5, May 2020, pp. 1829-1837, <https://www.ijsr.net/getabstract.php?paperid=SR24103125946>
8. B. Balkhi, A. M. Al-Shahrani, and A. Khan, "Just-in-time approach in healthcare inventory management: Does it really work?," *Saudi Pharmaceutical Journal*, vol. 30, no. 12, pp. 1830–1835, Dec. 2022, doi: 10.1016/j.jsps.2022.10.013.
9. X. Zhu, S. K. Mukhopadhyay, and H. Kurata, "A review of RFID technology and its managerial applications in different industries," *Journal of Engineering and Technology Management*, vol. 29, no. 1, pp. 152–167, Jan. 2012, doi: 10.1016/j.jengtecman.2011.09.011.
10. G. Wang, A. Gunasekaran, E. W. T. Ngai, and T. Papadopoulos, "Big data analytics in logistics and supply chain management: Certain investigations for research and applications," *International Journal of Production Economics*, vol. 176. Elsevier BV, pp. 98–110, Jun. 2016. doi: 10.1016/j.ijpe.2016.03.014.