PETRA IJBS VOL. 7, NO. 2, DECEMBER 2024: 158-174 DOI: https://doi.org/10.9744/petraijbs.7.2.158-174
E-ISSN 2621-6426

A Systematic Literature Review on Hospital Supply Chain Management: Exploring Hospital Types, Methodologies, SCOR Framework, and Technological Innovations

Marla Setiawati, Christofer Yehuda*, Damasus Dista Bima, Richardo Halim, Yoshua Mayo
Institut Teknologi Harapan Bangsa, Jl. Dipatiukur 80, Bandung 40132, Indonesia
*Corresponding author; E-mail: ti-21007@students.ithb.ac.id

Abstract

This paper provides a systematic literature review of hospital supply chain management (SCM), emphasizing variations across hospital types, methodological frameworks, the SCOR model, and technological advancements. Using the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology, the study systematically identifies, screens, and synthesizes relevant research to ensure comprehensive and high-quality data. The article selection process was done through a multiple screening procedure by four researchers, who collaboratively assessed data quality and relevance to the research topic. Individual researchers then further evaluated each identified article to avoid bias and ensure objectivity in the selection process. It highlights unique SCM challenges public and private hospitals face, particularly in resource allocation and technology adoption. Constrained by budget limitations, public hospitals often depend on collaborations and streamlined processes to ensure essential supplies. In contrast, private hospitals leverage technological tools such as AI, IoT, and blockchain for real-time data analysis and efficiency gains. Key SCM methodologies reviewed include Deep Reinforcement Learning, Multi-Criteria Decision-Making frameworks, and simulation modeling, each offering diverse benefits in cost management, inventory control, and decision support. The SCOR framework's applicability to hospitals is also discussed, emphasizing areas for process optimization and patient care improvements. The study concludes with insights into strategic SCM practices that support operational resilience, efficiency, and patient outcomes across hospital types, urging future research on scalable, technology-driven SCM solutions for healthcare institutions.

Keywords: Hospital Supply Chain Management, Public Hospitals, Private Hospitals, SCOR Framework, Technological Innovations, Systematic Literature Review, PRISMA.

1. Introduction

Hospitals play a foundational role in the healthcare system by delivering essential curative and preventive services, which are integral to public health. As described by the World Health Organization (WHO), hospitals are complex organizations that deliver diverse services, ranging from diagnosis and treatment to rehabilitation (Setiawati et al., 2023). Even with this development and expansion, hospitals are among the institutions that have day to day operational problems. Such challenges that include insufficient resources, irrational distribution methods and obsolete technology infrastructure make it evident that there exists an urgent need for professionally competent management of the supply chain within the hospital environment to achieve US DoD objectives (Kwon et al., 2016; Arora et al., 2018; Feibert et al., 2019).

What is interesting in this regard is the fact that there is a particularly pronounced variability of SCM between different types of the hospitals. On the one hand, public institutions are usually constrained within severe budget constraints and as a result develop different SC management challenges from those of the private hospitals that usually have wider latitude in resource use and technology adoption. Public institutions may be afflicted by SCM development deficiencies as a result of global inefficiency while dominant private institutions on the other hand, seem to always adopt the modern system and data to further their productivity and customer satisfaction (Duque-Uribe et al., 2019; Aryee et al., 2008). Understanding how and why these differences occur is important because they help to formulate the strategic orientation that will best serve the appropriate hospital type, thereby facilitating the effective deployment of resources and services across the various hospitals and other health care organizations.

A second important aspect of hospital supply chain management (SCM) is the multitude of strikingly different approaches that are developed for increasing efficiency and slashing operational expenditures. For example, Deep Reinforcement Learning (DRL) has shown promise in automating SCM complexities like inventory or logistics management by virtue of data mining (Ahmadi et al., 2019). Furthermore, MCDM techniques in combination with simulation models assist hospitals in the selection of SCM strategies by enabling trade-offs among several targets such as costs, quality, and security which are crucial in public hospitals most of which operate on limited budgets (Aldrighetti et al., 2019). Nonetheless, systematic review of literature on these methodologies in varying hospital types, particularly in their applicability and effectiveness in low-resource settings, is substantially limited

The SCOR (Supply Chain Operations Reference) frame-work provides a systematic approach on how to assess and enhance SCM processes in different fields; prevalence in hospital SCM still remains largely overlooked. This review intends to demonstrate how the SCOR can be used to improve the operations of the hospitals in different areas by focusing on the SCOR model's five building blocks of plan, source, make, deliver, and return (Ageron et al, 2018). The same SCOR implementation approach in private hospitals and the other public surviving hospitals can lead to positive comparative advantages which dictate special SCM practices for efficiency, cost cuts, and better patient outcome.

In conclusion, the adoption of technological progress in SCM in hospitals shows great prospects to tackle the operational difficulties, especially for the private types of hospitals which have relatively ample financial resources. According to (Abugabah et al., 2020) and (Gendy et al., 2019) hospitals are now able to make the right inventory management decisions and have the capacity to optimize processes by utilizing the Internet of Things (IoT), Artificial Intelligence (AI) and data analytics which allow them to track and predict needed processes in real time. On the other hand, public institutions, which are disadvantageous to these modern technologies, stand to have challenges in utilizing contemporary SCM systems and this emphasizes the need for innovative and cost-effective, integrable solutions to narrow this technological divide and maintain the required standards in healthcare services for the different types of hospitals.

This systematic literature review seeks to fill these knowledge gaps by studying SCM practices in the SCM in the public and private hospitals, assessing the effectiveness of such approaches as DRL, MCDM, and simulation, as well as the role of innovations and the SCOR model on the SC of hospitals. The scope of these dimensions calls for a more comprehensive understanding and improvement of hospital SCM within the context of these social spheres so that effective strategies for improving operational efficiency, lowering costs, and enhancing patient services in a wide range of healthcare settings are developed.

2. Literature Review

2.1. Hospital Supply Chain Management (HSCM)

Hospital supply chain management (HSCM) is described as a broad web of interaction involving the hospitals, suppliers, and government aimed at the effective distribution of the medical goods and services. This research points to the fact that the hospital supply chain, as a system, is dependent on conditions that enhance its performance namely, coordination, collaboration and integration. Effective collaboration with the suppliers and the government facilitates the flow of information and goods and thus enhances the quality of service and patient care. Other factors including trust, supplier quality assurance systems, inventory systems and technology affect hospital supply chain performance and even enhance it as the study shows. In the systems thinking applied in this research, the systems dynamics approach allows illustrating partnerships amongst the key stakeholders to be useful in enhancing the performance of the whole hospital supply chain (Setiawati et al., 2023).

2.2. Hospital Type

Hospitals have specific functions in the medical and public health (PH) systems. Most of the hospitals fall under two categories of public and private, who differ primarily in terms of funding, ownership and organization structure.

Thinking of the bigger picture, public healthcare institutions get financial resources from the budgets of the governments. Nonetheless, modern supply chain systems are hardly used, if ever, because of budgetary limitations. In the course of the COVID-19 outbreak, public institutions struggled with inventory for critical medicine and equipment, which diminished the robustness and sustainability of supply chains in public health (Jifar et al., 2022).

Due to the budget constraints, public hospitals work with government as well as non-government organization especially in emergencies. The former strengthens the supply chains while the latter together with logistical challenges weaken effectiveness. As a result, public hospitals do not seek new technologies, but stick to their current suppliers. While this guarantees the continuity of service delivery, it does not give the ability to quickly respond to unanticipated shifts in demand leaving an opportunity for low cost and flexible supply chain management (Li and Martins et al., 2024).

Funding from the private sector in private hospitals reduces complexity in supply-chain issues as these hospitals have greater integration and more readily embrace new ideas. Their competitors drive use of automation and analytics in order to strategically allocate resources and be responsive to demand (O'Mahony et al., 2021).

Lean and agile strategies applied in private settings enable waste minimization and compliance with situational requirements (Li and Martins et al., 2024). Such delays can be avoided by utilizing real time measures to determine the movement of stock and achieve just the right quantity without going to excess stock. This technological advantage enables the management of the supply chains by private hospitals without compromising the quality of care at high peak seasons.

2.3. Methodologies

To enhance the effectiveness, strength, and quality of service, various strategies are currently put to use in the hospital supply chains. They, therefore, seek to minimize resource underutilization, create efficient systems for curbing inventory stock outs, and enhance the rerouting of procurement.

Forecasting inventory requirements due to changes in demand over time works best when applying simulation approaches. Simulation enables the hospitals to plan their inventory flexibly so that stockouts are avoided. According to (Jifar et al., 2022), depending on the planning processes that are used, simulation-based planning allows a hospital to prepare for surges on demand that can cause a significant amount of wastage, which improves efficiency in managing the inventory. Such Simulation models allow estimation of peak times so that hospitals can plan their allocation of resources and avert critical resource depletion in times of emergency.

Deep Reinforcement Learning, DRL for short, and a machine learning paradigm deal with the optimal management of inventories in real-time. In the case of hospital supply chains, DRL operates by establishing the quantity of stock required for various demands, hence a more flexible approach to volunteering. (See Bialas et al., 2023), DRL contributes towards achieving risk minimization objectives for hospital stockouts and maximizes the availability of distribution whenever the demand for pharmaceuticals or medical equipment varies. Stock levels as a measure of demand are periodically reviewed, managed and maintained with DRL to minimize the need for hospitals to frequently make purchases and to avert stockouts.

Multi-Criteria Decision Making (MCDM) can be defined as a systematic approach which takes into consideration multiple dominant factors in terms of SCM. Economics, available resources, flexibility, and eco-friendliness are among the several aspects appreciated by MCDM. (Nouranian et al., 2021) argued that a key advantage of MCDM is its usefulness in strategic decision making by hospitals when there are high levels of uncertainty like during a pandemic or outer space crisis. It also helps avoid scenarios like overreliance on a single factor by providing a broader perspective to decision making.

Literature review enables hospitals' supply chain managers to appreciate the ongoing developments in the field, their pitfalls and possible ways of overcoming them. Best practices showing success in overcoming bottlenecks, successful change in strategies and other positive innovations could be deployed by hospitals through review of literature. (Ziat et al., 2019) underscored the place of literature reviews in the design of the hospital supply system. To do this, however, literature recommended the need for a proper analysis of existing literature to avoid unnecessary and costly experimentation.

2.4. SCOR (Supply Chain Operations Reference)

As outlined by the SCOR model, there are operational supply chain elements in the hospital which include sourcing, procurement, production as well as returns. The model has five building blocks: Source, Plan, Make, Deliver, and Return.

Sourcing encompasses working with suppliers to develop a steady supply of the resources needed. During the COVID-19 crisis, close supplier partnerships helped to guarantee critical product inventories (Hu et al., 2023). Blockchain technology has promoted the source of the products by providing proof of the legitimacy and authenticity of the products, reducing counterfeit drugs in healthcare.

Ample planning enhances the capacity of hospitals to meet the medical needs of the people, especially during times of crisis. Digital planning tools incorporate forecasting features such as demand forecasting and resource allocation, enabling optimal stock-level maintenance by hospitals (Bø et al., 2023). These tools forecast demand, which is important for future stocking requirements and helps avoid stock wastage.

In the make phase, drugs and blood supply have controlled production environments. Automation technologies improve production efficiency; thus, adequate supply is assured, and wastage is kept to a minimum. Laboratory automation enhances the accuracy and speed of production processes, and thus, hospitals can meet their demands without compromising the quality of products (Shen et al., 2024).

In the case of emergencies, fast delivery of medical materials is needed. Quick inventory management enables hospitals to position resources quickly in zones of high demand. Internal inventory management systems, also provided by (Pratono et al., 2023), allow more flexibility in operations and timely provision of necessary materials, improving emergencies during a crisis.

It is a common occurrence when unused or expired items are sent back. The same RFID technology allows the returns to be monitored and controlled, assisting hospitals in managing their stock levels. Such technology wins over waste and enhances resource allocation in the hospital supply chain networks (Neve et al., 2021).

2.5. Technology and Innovation

Hospitals' supply chain management benefits from the use of new and advanced information technology by increasing efficiency and resilience.

Through the analysis of real-time data, machine learning reduces the amount of overstocking and, at the same time, guarantees enough stock to be supplied. This culminates into an effective inventory control (Setyaningrum & Muafi et al., 2023).

In addition, the use of Blockchain creates higher traceability levels within the medical supply chain, which, in turn, mitigates the chances of counterfeits and secures the drugs' integrity (Jamil et al., 2019).

IoT networks support the adequate transportation of temperature-sensitive products with the environment and the conditions within the packaging of the products (Setyaningrum & Muafi et al., 2023).

GSCM lowers the hospitals' carbon footprint due to environmentally responsible resource use and management policies incorporated into the supply chain. It conserves energy and resource consumption and eliminates wastes that are not sustainable (Setyaningrum & Muafi et al., 2023).

Supply chain resilience is necessary to diminish service disruptions since it enables hospitals to function normally and deliver care despite interruptions. Hospitals can endure stress and still provide decent quality care through flexible measures (Li and Martins et al., 2024).

Also, lean implementations focus on elimination of wastes to help in the improvement of the hospital supply chain. The reduction in excess stocks and the maximization of resource use helps in making sure that services are timely and the devotion of resources is also useful (O'Mahony et al., 2021).

3. Methods

This systematic review was performed concerning the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) recommendations so that the review and the process is systematic and easy to follow as outlined (Setiawati et al., 2024) and (Li et al., 2024). PRISMA is particularly useful for systematic reviews since it assists researchers with the accurate conduct, reporting, and evaluation of the studies, resulting to a more reproducible and quality research process.

3.1. Search Strategy

A systematic search was performed in two main databases, Scopus and Search Rabbit, to find relevant publications for this review. The search strategy included specific keywords to meet the healthcare sector supply chain barriers in scope. These keywords were "Shortage," "Scheduling (delay)," "Automation," "Resource Constraints," "System," "Information," "Technology," "Inventory Management," "Supplier Dependency," "Inefficient Distribution," and "Inefficient Cost." Such terms were used in the titles, keywords, and abstracts to retrieve the relevant articles. From the first search, a total of 244 records were captured.

3.2. Screening Process

At the end of stage one, where a search was conducted, some records were found to be repetitive, and these were expunged, leading to 192 such documents for further scrutiny. In this case, the remaining articles were analyzed, particularly their abstracts, to determine their relevance to the main study's focus question. Articles not related to the core keywords "supply chain management" and "hospital" were dropped because they did not fall within the scope of the particular study, which is supply chain management in the healthcare field. The broad theme of the article bible in review undertook to classify articles outside this scope. It narrowed the focus to 138 relevant articles based on the set criteria. This was done through an additional verification step that looks at ra the papers selected to determine their credibility and quality by determining whether they appeared in the Scimago database. Indexing in Scimago indicated journal quality and ensured that only credible sources were included in the review. After this verification process, only articles indexed in Scimago were retained, reducing the total number of articles to 80.

3.3. Eligibility Assessment

Each publication underwent further evaluation in the eligibility phase to ensure it met all additional inclusion criteria, particularly regarding comprehensive content and full-text availability based on its abstract. Articles were excluded if they did not meet this standard, provided limited information, or focused on topics outside the intended scope. Expressly, articles centered on individual diseases, disease-specific management, or blood management were excluded, as they did not align with the broader scope of healthcare supply chain management addressed in this study. This eligibility assessment led to the exclusion of an additional 15 articles, resulting in 65 articles that fully met the criteria for inclusion in the review.

3.4. Final Inclusion

After the eligibility assessment, the number of articles that satisfied all inclusion criteria stood at sixtyfive, making it into this systematic review. On the other hand, the selected article deals with some components of supply chain management in hospitals or within the healthcare domain. Major themes and topics addressed in the articles included in this review include inventory control, supplier dependency, resource allocation, and operational inefficiencies linked to healthcare provision. Given the focus on these core topics, this review seeks to enhance understanding of the problems and solutions in the healthcare supply chain management field.

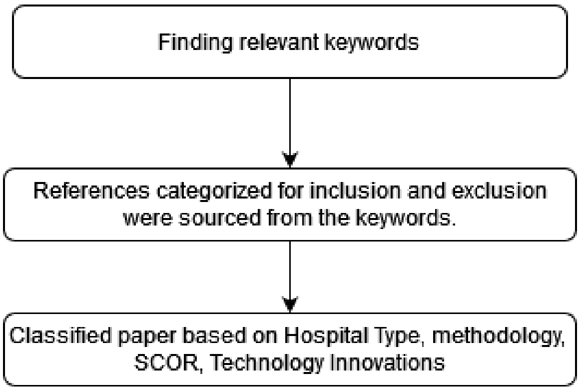

Figure 1. Strategy to conduct the state-of-the-art

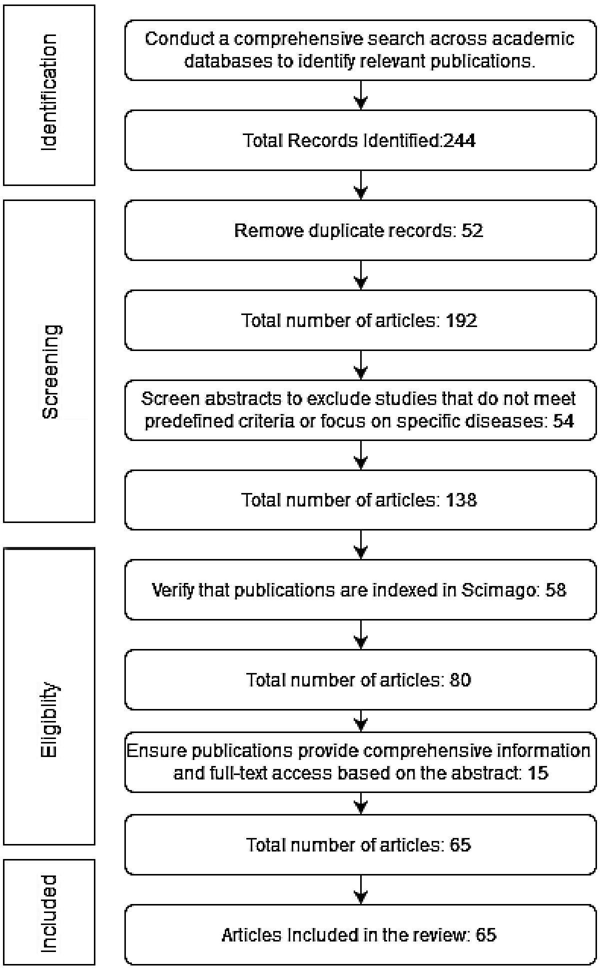

Figure 2. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses

The conclusions obtained from these 65 articles are expected to add new dimensions and knowledge in terms of the strategies, technologies, and frameworks relevant to the management of healthcare supply chains. Such knowledge can help healthcare institutions improve their supply chain management, minimize expenses incurred, improve punctuality in the delivery of medical supplies and enhance the quality of care offered to the patients. The systematic selection and literature analysis further emphasize the importance of appropriate supply chain management practices in addressing the increasing demand for healthcare services and resources.

4. Result

Utilizing the systematic PRISMA approach, 65 articles were found useful and were grouped for analysis into four major themes: Hospital Types, Methodologies, SCOR Framework, and Technology and innovation. The literature touched upon all the categories of patterns, variations, strengths, and limitations. There was more focus on categories, with few studies facilitating a more in-depth and extensive analysis.

4.1. Hospital Type

Public Hospitals: A total of 48 studies focused on public hospitals, as seen in Table 1, which predominantly aim to provide essential and affordable healthcare services supported by government funding to ensure broad access (Beaulieu et al., 2021; Shahbahrami et al., 2024). Most of the studies argue that in circumstances where public institutions focus on SCM, it is to optimize stock levels of medicines and medical inventory efficiently (Martín-Blanco et al., 2022; Islam et al., 2023). Public hospitals have key advantages, such as better crisis preparedness in urban areas due to structured supply chain management and robust infrastructure (Neve & Schmidt et al., 2021;

Sienkiewicz-Małyjurek & Szymczak et al., 2023). Despite limited resources, they also provide essential basic healthcare services in remote regions (Kwan et al., 2020; Holm et al., 2015). Although less flexible than private hospitals, their compliance with regulations ensures consistent and reliable service standards (Setiawati et al., 2023).

Private Hospitals: In 15 studies examining private hospitals, a consistent trend emerges in the adoption of SCM practices aimed at operational efficiency and high-quality patient care, facilitated by digital technologies in inventory and distribution management (Ahmad AlBrakata et al., 2023; Lau et al., 2022). Larger private hospitals frequently employ technology to monitor drugs and utilize AI for forecasting analytics in managing supplies, whereas smaller hospitals typically stick to digital approaches (Jamil et al., 2019; George & Elrashid et al., 2023). As per Nabelsi and Gagnon et al. (2016), private hospitals excel in accommodating market needs due to their capacity to invest in emerging technologies. Comparison of the differences and shortcomings between public and private hospitals, see Table 1.

Table 1. Overview of hospital types in healthcare supply chain management

Hospital Type	Nr. of Article	Differences	Weaknesses	Reference
Public Hospital	48	In several publications on technology, adoption, sustainability, and supply chain management, major contrasts in approaches public hospitals are noticeable. While some highlight the importance of digitalization and AI/big data use, others consider a government health policy, inventories, and the COVID-19 pandemic consequences for the operation of hospitals. The use of new technologies, such as blockchain, in pharmaceutical supply chains is discussed in many papers. Furthermore, there are differences in applying these theories in larger and smaller hospitals, as well as the health systems employed in these hospitals.	An important gap that has been noticed in all the articles is the poor coupling/linkage of the advanced technology with the hospital organization as a whole. Furthermore, several public hospitals also have budgetary and resource base limitations, which hinder them from adopting technology or even technologies in supply chain management. Also, there is a dearth of detailed discussion on regulatory issues and challenges to innovation in this industry. Several articles concentrate on simulation business models but do not include practical solutions or assessments of the business after implementation. One more problem is the lack of adequate consideration of the viability and lasting effects of the envisaged policies or technologies on the quality of care for patients.	Ahtiainen, H. K. et al. (2020). al Moteri, M., & Alojail, M. (2023), Allahham, M. et al. (2023). Beaulieu, M., & Bentahar, O. (2021). Bialas, C. et al (2023). Bø, E. et al. (2023). Health Services Management Research. (2018). Bvuchete, M. et al. (2021). Chen, D., & Wanbon, R. (2023). Chiang, C., & Chuang, M. C. (2024). Ding, B. et al. (2024). Dorgham, K. et al. (2022). Duque-Uribe, V. et al. (2019). El-Garaihy, W. H. et al. (2022). Emadi, P., & Pasek, Z. J. (2021). Holm, M. R. et al. (2015). Hu, H. et al. (2023). Improta, G. et al. (2021). Islam, S., & Habib, Md. M. (2024). Islam, S. et al. (2023). Ivanov, D., & Dolgui, A. (2022). Jifar, W. W. et al. (2022). Kachwee, M., & Hartmann, M. D. (2013). Karbassi Yazdi, A. et al. (2022). Khot, U. N. (2020). Kochakkashani, F. et al. (2023). Kwan, W. M. et al. (2020). Latonen, S. H. et al. (2023). Lau, Y. Y. et al. (2022). Leaven, L., & Ahmmad, K. (2017). Li, X., & Martins, A. L. (2024). Lotfi, R. et al. (2022). Marques, L. et al. (2020). Martín-Blanco, C. et al (2022). Mirghafoori, S. H. et al. (2018). Mittal, A., & Mantri, A. (2023). Modisakeng, C. et al. (2020). Nabelsi, V., & Gagnon, S. (2017). Neve, B. v., & Schmidt, C. P. (2022). Nouranian, M. et al. (2021). Pamucar, D. et al. (2023). Pratono, A. H., & Maharani, A. (2023). Setiawati, M. et al (2023). Setyaningrum, R., & Muafi, M. (2023). Shahbahrami, E. et al. (2024). Shen, J. et al. (2024). Shih, H., & Rajendran, S. (2020). Shokouhifar, M., & Ranjbarimesan, M. (2022). Sienkiewicz-Małyjurek, K., & Szymczak, M. (2024). Socal, M. P. et al. (2020). Spieske, A., Gebhardt, M., Kopyto, M., & Birkel, H. (2022).Spieske, A. et al (2022). Sporrong, S. K. et al. (2016). Tatiana, E. et al. (2023). Uthayakumar, R., & Priyan, S. (2013). Yu, Z. (2023). Ziat, A. et al (2020). Ziat, A. et al. (2024). Zwaida, T. A. et al. (2021).

Private Hospital	15	The literature on private healthcare institutions indicates different perspectives. Some researchers address the implications of implementing new technologies such as AI, blockchain or other computer-based systems in supply chain management, while others research the classic models of inventory management systems. There are also differences in hospital type, with some papers focused on the single-specialty hospital market, such as in the case of cardiology clinics, while others concentrate on the multispecialty case. Models of payment also differ, as there are some hospitals paid through self-payment and some are through private health insurance. All in all, the differences serve to highlight the scale, technology adoption and integration of private health institutions.	The funding dependency pattern is perhaps the most serious problem with private hospitals as it cuts out the poorer patients while, at the same time, the smaller private hospitals face competition with regard to capacity and care. Patients are left in the dark about price because there is no transparency in that. Likewise, organizational factors such as the non compliance with the performance standards lead to mismanagement and subsequent low quality of care. Very high costs, most of the time unreasonably high in the eyes of people, serve to put these people out of the reach of key medical primary care services.	Al-Nawafaha, S. S. et al. (2022). AlBrakata, N. S. A. et al. (2023). Allahham, M. et al. (2023).Health Services Management Research. (2018). George, S., & Elrashid, S. (2023).Jamil, F. et al. (2019). Lau, Y.-Y. et al. (2022).Liu, W. et al. (2019). Marques, L. et al. (2019). Nabelsi, V., & Gagnon, S. (2016). O'Mahony, L. et al. (2021). Sakly, H. et al (2021). Ruíz Orjuela, E. T. et al (2023).Ziat, A. et al. (2019).Ziat, A. et al. (2022).

4.2. Methodology

Simulation: There have been 15 studies conducted regarding simulation, as shown in Table 2, highlighting the effectiveness of simulations in addressing uncertainties and improving performance through scenario assessments (Improta et al., 2021). Simulation models predict inventory needs and align resource distribution with demand (Islam et al., 2023).

Deep Reinforcement Learning (DRL): 5 studies explore DRL as an innovative approach to optimize SCM by addressing demand fluctuations and complex datasets, making DRL useful for real-time decision-making (Allahham et al., 2023; Hu et al., 2023; Lotfi et al., 2022). Each study, however, brings a unique focus, as seen at Table 2.

Multiple Criteria Decision Making (MCDM): Another 15 studies employ MCDM techniques like AHP and BWM to facilitate decision-making in SCM. MCDM allows hospitals to assess multiple strategic options objectively, promoting transparency and consistency (Al-Nawafah et al., 2022; Yazdi et al., 2022).

Literature Review: With 31 studies using systematic literature reviews, this method is widely adopted to identify trends and consolidate findings in supply chain management (SCM) research. Literature reviews provide a comprehensive overview of existing research, offering valuable insights into the state of the field. For differences and drawbacks, see Table 2.

Table 2. Methodologies applied in healthcare supply chain research

Methodology	Nr. of Article	Differences	Weaknesses	Reference
Simulation	15	Different models are used in simulation studies. Some focus on system dynamics to evaluate policies' effects on drug supply chains, while others use digital twin technology for hospital logistics optimization. Some studies employ stochastic modeling for blood supply uncertainty	Simulations require precise data with high computing power, which can take considerable time to produce reliable results. Additionally, errors in choosing the right model or using inaccurate data	Al Moteri & Alojail (2023); Chen & Wanbon (2023); Dorgham et al. (2022); Emadi & Pasek (2021); Improta et al. (2021); Jamil et al. (2019); Kochakkashani et al. (2023); Liu et al. (2020); Neve & Schmidt (2021); O'Mahony et al. (2021); Sakly et al. (2021); Setiawati et al. (2023); Shahbahrami et al. (2024);

		management and Lean Six Sigma for cost reduction and efficiency improvement.	can lead to unreliable outcomes.	Shih & Rajendran (2020); Uthayakumar & Priyan (2013)
Deep Reinforcement Learning (DRL)	5	There is variation in the focus of DRL applications. Some studies generate desire, while others incorporate technologies such as blockchain, IoT, and neural networks into their applications. DRL is also being applied to power drug delivery and improve decision-making through real-time feedback002E	DRL requires significant investment in technology and specialized data expertise, limiting its application in hospitals with limited budgets. Additionally, DRL relies on high-quality data to produce optimal results, which can be challenging for hospitals with inadequate IT infrastructure.	Allahham et al. (2023); Hu et al. (2023); Lotfi et al. (2022); Ziat et al. (2020); Zwaida et al. (2021)
Multi-Criteria Decision Making (MCDM)	14	In the simulation studies, different models are applied. Some use system dynamics to evaluate policy impacts on drug supply chains, while others apply digital twin technology to optimize hospital logistics. Stochastic modeling handles blood supply uncertainties, and Lean Six Sigma approaches focus on reducing costs and improving efficiency.	Simulations require highly accurate data, substantial computational power, and often long processing times to yield valid results. Also, model selection errors or inaccurate data can lead to unreliable outcomes.	Al-Nawafah et al. (2022); Albrakat et al. (2023); Bialas et al. (2023); Chiang & Chuang (2024); George & Elrashid (2023); Islam & Habib (2024); Islam et al. (2023); Karbassi Yazdi et al. (2022); Kwan et al. (2020); Mirghafoori et al. (2018); Nouranian et al. (2021); Pamucar et al. (2023); Setyaningrum & Muafi (2023); Yu (2023)
Literature Review	31	The literature review approaches vary widely. Some articles use the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) approach to structure systematic reviews and ensure quality and transparency, while others incorporate VOSviewer for bibliometric analysis to visualize relationships between articles. Some rely solely on qualitative reviews of secondary data, or combine expert interviews for additional insights.	These approaches are limited to secondary data and may be affected by publication bias. The process of gathering additional data requires significant time and resources.	Ahtiainen et al. (2020); Beaulieu & Bentahar (2021); Bø et al. (2023); Buttigieg et al. (2020); Bvuchete et al. (2021); Ding et al. (2024); Duque-Uribe et al. (2019); El-Garaihy et al. (2022); Holm et al. (2015); Ivanov & Dolgui (2022); Jifar et al. (2022); Kachwee & Hartmann (2013); Khot (2020); Latonen et al. (2023); Lau et al. (2022); Leaven & Ahmmad (2017); Li & Martins (2024); Marques et al. (2020); Martín-Blanco et al. (2022); Mittal & Mantri (2023); Modisakeng et al. (2020); Nabelsi & Gagnon (2017); Pratono & Maharani (2023); Shen et al. (2024); Shokouhifar & Ranjbarimesan (2022); Sienkiewicz-Małyjurek & Szymczak (2024); Socal et al. (2021); Spieske et al. (2022); Sporrong et al. (2016); Tatiana et al. (2023); Ziat et al. (2024)

4.3. SCOR Framework

Source: 18 studies concentrate on the *Source* component, leaning towards the fact that there is always a need for developed relationships with suppliers and that their inventories are managed accurately and in real-time. Relationships with suppliers help hospitals overcome supply chain vulnerability, particularly during crises (Nouranian et al., 2021; Setiawati et al., 2023).

Plan: The *Plan* phase is central in 28 studies, where IoT and machine learning are employed to enhance visibility and demand responsiveness in SCM (Islam et al., 2024; Shokouhifar et al., 2022). These technologies are highly effective for forecasting and optimizing stock levels.

Make: In 8 studies on the *Make* phase, automation and digitalization in production processes are prominent, with tools like digital twins and RPA playing a key role in minimizing errors and improving efficiency (Neve et al., 2021; Liu et al., 2020).

Deliver: 5 studies focus on the *delivery* phase, examining logistics and distribution to ensure that medical products reach patients promptly (Gunasekaran et al., 2004; Al-Hawary et al., 2022). Tracking technology and warehouse management systems are essential for accuracy and efficiency in delivery operations (Lambert et al., 2001; Scholten & Schilder et al., 2015).

Return: 8 research works on the Return phase discuss the challenges that arise in the process of product return or product recall, resulting in the product system's endurance.

Table 3. SCOR framework applications in hospital supply chain management

SCOR	Nr. of Article	Differences	Weaknesses	Reference
Source	18	The articles differ in their approaches to sourcing management in hospital supply chains, with some focusing on sustainability while others prioritize digital technologies for efficiency and transparency. There are also discussions on risk management and supplier relationships, with approaches varying based on factors like the COVID-19 pandemic and environmental considerations.	Sourcing management faces several challenges, including dependency on global suppliers, limited flexibility in sourcing systems, and insufficient integration of technology. There is also a lack of focus on sustainability in sourcing practices. To improve sourcing, hospitals must enhance supplier relationship management, emphasize strategic sustainability, and adopt standardized processes. Additionally, thorough supplier evaluations are crucial to ensure supply continuity and service quality.	Al Moteri et al. (2023), Albrakat et al. (2023), Allahham et al. (2023), Beaulieu & Bentahar (2021), Bvuchete et al. (2021), Chen & Wanbon (2023), Ding et al. (2024), Duque-Uribe et al. (2019), El-Garaihy et al. (2022), Hu et al. (2023), Islam & Habib (2024), Karbassi Yazdi et al. (2022), Kochakkashani et al. (2023), Kwan et al. (2020), Li & Martins (2024), Lotfi et al. (2022), Mirghafoori et al. (2018), Nabelsi & Gagnon (2017), Pratono & Maharani (2023), Setyaningrum & Muafi (2023), Shahbahrami et al. (2024), Shih & Rajendran (2020), Shokouhifar & Ranjbarimesan (2022), Spieske et al. (2022), Tatiana et al. (2023), Yu (2023), Ziat et al. (2024).
Plan	28	The papers differ in planning approaches, highlighting technological integration (AI, big data, blockchain) versus physical capacity and system collaboration. Many emphasize sustainability and crisis adaptation, focusing on resilience and rapid response to changes.	The hospital supply chain planning across the papers faces challenges such as high technology costs, limited infrastructure, data quality reliance, and managing change. Issues also include the scale of technology adoption, long-term crisis adaptation, system integration, and measuring planning success. Despite promising technological solutions, effective implementation and maintenance require overcoming these obstacles.	Ahtiainen et al., (2020), Bialas et al., (2023), Chiang & Chuang, (2024), Dorgham et al., (2022), Holm et al., (2015), Islam et al., (2023), Jamil et al., (2019), Lau et al., (2022), Marques et al., (2020), Mittal & Mantri, (2023), Nouranian et al., (2021), Pamucar et al., (2023), Setiawati et al., (2023), Shen et al., (2024), Sienkiewicz-Małyjurek & Szymczak, (2024), Sporrong et al., (2016), Uthayakumar & Priyan, (2013), Zwaida et al., (2021).
Make	8	These eight reviewed papers view healthcare supply chain management from different perspectives, including green supply chain practices and operational performance, impacts of COVID-19, blockchain for assurance of drug integrity, Lean Six Sigma strategies, and sustainability in performance management. They reflect a wide variety of themes in the area of operational, technological, sustainability, data integrity, and resilience perspectives in healthcare supply chains.	Hospital supply chain studies within the SCOR framework show shortcomings, including over-reliance on complex technologies, limited case studies, and inaccurate data affecting model accuracy. The focus is mainly on cost reduction and operational efficiency, with little attention to patient care quality or the long-term impacts of new systems. Additionally, the role of staff in maintaining systems and optimizing labor is often neglected.	Buttigieg, S. C., et al. (2021). George, S., & Elrashid, S. (2023). Kachwee, M., & Hartmann, M. D. (2013). Leaven, L., & Ahmmad, K. (2017). Liu, W., Zhang, W., Dutta, B., Wu, Z., et al. (2020). Neve, B. V., & Schmidt, C. P. (2022). O'Mahony, L., McCarthy, K., O'Donoghue, J., et al. (2021). Sakly, H., Said, M., & Tagina, M. (2021).

Deliver	5	These five papers explore different approaches to improving the "Deliver" stage in the SCOR Framework, including social media for communication, green supply chain practices, Big Data and AI for predictive analytics, better supplier coordination, and pharmaceutical inventory management. Each focuses on enhancing delivery through technology, sustainability, and inventory management.	The five papers on the "Deliver" aspect of the SCOR Framework have key limitations: the first overlooks long-term social media effects, the second focuses only on green supply chain costs, the third ignores resource constraints, the fourth is geographically limited, and the fifth neglects the impact of inventory on patient care. None address external factors or practical implementation challenges.	Al-Nawafah et al., (2022); S.H. Latonen et al., (2023); Giovanni Improta et al., (2021); ; Parmis Emadi et al., (2021),Umesh N. Khot et al., (2020)
Return	6	The studies on the "Return" aspect of the SCOR Framework highlight challenges like pharmaceutical waste, damaged products, and circular economy practices. Differences lie in the emphasis on digital technology integration, contract management, and inventory accuracy to overcome logistical issues, with a focus on improving supply chain resilience through better return management.	The "Return" aspect of the SCOR Framework faced challenges during COVID-19, including inaccurate inventory, supplier delays, and inadequate infrastructure, especially in resource-limited areas. Limited use of the circular economy hindered waste and defective product management. Pandemic disruptions slowed returns and increased costs, highlighting the need for stronger technologies, policies, and cross-sector collaboration.	Bø et al. (2024), Ivanov et al. (2022), Jifar et al. (2022), Martín-Blanco et al. (2022), Modisakeng et al. (2020), Socal et al. (2021).

4.4. Technology & Innovation

Machine Learning: Machine learning was helpful in demand forecasting and inventory activities in 13 studies. Machine learning aids in the allocation of resources, thereby decreasing deficient stocks and increasing the availability of critical stock (Sho-kouhifar et al.,2022; Abu Zwaida et al., 2021

Blockchain: 2 researches highlight the role of blockchain as a transformative technology in SCM, improving data protection and information transparency. Thanks to blockchain, tracking can be done effectively to ensure the preservation of product value and guard against fakes, which is important in the supply chains of vaccines and drugs (Hu et al., 2023; Jamil et al., 2019).

IoT: 12 research papers investigate how the Internet of Things (IoT) contributes towards offering real-time data monitoring for making decisions in managing hospital logistics effectively. The IoT plays a role in enhancing visibility and streamlining hospital supply chain management processes.

Sustainability: A total of 8 research papers explore supply chain management (SCN) approaches like Green Supply Chain Management (GSCN) to lessen footprints and boost operational effectiveness. These studies acknowledge the challenges of incorporating methods into systems due, to their costly nature and resource constraints (Setyaningrum & Muafi et al., 2023; Duque Uribe et al., 2019).

Resilience: 19 studies emphasize resilience-focused approaches in SCM to enhance crisis readiness. Resilience strategies reduce risk during disruptions.

Lean: 12 studies examine the application of lean management principles in the SCM stage in healthcare institutions, particularly emphasizing waste elimination and improvement (O'Mahony et al., 2021; Nouranian et al., 2021).

Table 4. Technological innovations in hospital supply chain management

Technology & Innovation	Nr. of Article	Differences	Weaknesses	Reference
Machine Learning	13	There are different applications of Machine Learning in this research, which include integrating Big Data and AI in supply chain sustainability and deep	This means that ML needs expensive and elaborate technological infrastructure that is not easily accessible by small companies. It also needs much	Allahham et al. (2023); Dorgham et al. (2022); Hu et al. (2023); Kwan et al. (2020); Lau et al. (2022); Lotfi et al. (2022); Mirghafoori et al. (2018); Pamucar et al. (2023);

		Reinforcement Learning (DRL) in inventory optimization to minimize drug shortages. Some of the research focuses on demand forecasting and pharmaceutical supply chain management.	data, and training the models is very complex and can take much time. Using other technologies, such as Blockchain and IoT, also presents new implementation issues.	Shen et al. (2024); Shokouhifar & Ranjbarimesan (2022); Zwaida et al. (2021); Shahbahrami et al. (2024); Uthayakumar & Priyan (2013)
Blockchain	2	The use of Blockchain in hospital supply chains is mainly to improve the efficiency of data by improving the quality of shared data, especially in the management of vaccines and drugs. Blockchain combines Machine Learning (ML) and IoT to ensure data integrity and enhance supply chain traceability.	Blockchains are bulky and elaborate to build and face the problem of being accepted because they require much regulation and much funding in technology.	Hu et al. (2023); Jamil et al. (2019)
IoT	12	In this paper, IoT is depicted as enhancing the perception, the throughput, and the robustness of the hospital supply chains. Some research works implement IoT in supply chain management, as well as real-time data capture and sharing and integration with other technologies such as RFID, AI, digital twin, and barcode for tracking and monitoring inventory.	The IoT relies on expensive and complex infrastructure, has difficulties in assimilating with current systems, and has data privacy concerns because of the amount of data generated. Furthermore, ensuring data streaming integrity and accuracy also comes with its problems.	al Moteri & Alojail (2023); Beaulieu & Bentahar (2021); Bvuchete et al. (2021); Holm et al. (2015); Islam & Habib (2024); Leaven & Ahmmad (2017); Liu et al. (2020); Nabelsi & Gagnon (2017); Neve & Schmidt (2022); Sakly et al. (2021); Spieske et al. (2022); Tatiana et al. (2023)
Sustainable	8	Sustainable Supply Chain Management (SCM) manages the supply chain to reduce carbon footprints, emissions, and energy consumption and enhance operational efficiency of hospitals. Some research works also discuss sustainable procurement strategies. These practices are usually implemented together with the Green of HRM for organizations to enhance sustainability.	Sustainable SCM poses important challenges regarding costs and integration with current hospital infrastructure. The effects of sustainable practices can take years to become more apparent.	Albrakat et al. (2023); Chiang & Chuang (2024); Duque-Uribe et al. (2019); Islam et al. (2023); Karbassi Yazdi et al. (2022b); Setyaningrum & Muafi (2023); Ziat et al. (2020); Ziat et al. (2024)
Resilience	18	In a more specific view, the resilience of the hospital supply chains aims at adaptive responses, correct preparedness, and, more importantly, enduring any interruption that may arise in the process, for example, of a health outbreak (COVID-19) or challenges in the market. Some studies	Some, such as the limited significant infrastructure challenges and human resources, have been challenges experienced in the effective implementation integration of the resilience international resilience strategies suppliers strategies, such as who	Bø et al. (2023); Buttigieg et al. (n.d.); Chen & Wanbon (2023); Ding et al. (2024); Emadi & Pasek (n.d.); Ivanov & Dolgui (2022); Jifar et al. (2022); Khot (2020); Latonen et al. (2023); Kochakkashani et al. (2023); Marques et al. (2020); Martín-Blanco et al. (2022); Mittal & Mantri (2023); Modisakeng et al.

		emphasize cooperation across sectors, while others deal with the resilience of the pharmaceutical supply chain and the designing of resilience evaluation metrics for the networks of hospital supply chains.	and constraints are slow in their response.	(2020); Pratono & Maharani (2023); Shih & Rajendran (2020); Sienkiewicz-Małyjurek & Szymczak (2024); Socal et al. (2021)
Lean	12	In the hospital supply chains, Lean is used to minimize costs, increase efficiency, and improve the processes. It includes automation, efficient communication, and reduced costs and time. Some studies apply the Lean Six Sigma approach in their respective organizations while others apply Lean principles in inventory management, human resources management and supply chain planning.	Lean implementation involves implementing several processes and systems dependent on automation and integration of systems, which requires a huge initial investment. If not managed effectively, it can cause stock outs pressure. or At increase times, the Lean workload implementation can also reduce the overall flexibility as well as the response time in case of an event or crisis.	Ahtiainen et al. (2020); Al-Nawafah et al. (2022); Bialas et al. (2023); El-Garaihy et al. (2022); George & Elrashid (2023); Improta et al. (2021); Kachwee & Hartmann (2013); Li & Martins (2024); Nouranian et al. (2021); O'mahony et al. (2021); Sporrong et al. (2016); Yu (2023)

5. Discussion

This research sheds light on shortcomings in managing hospital supply chains in healthcare facilities by examining Deep Reinforcement Learning (DRL) implementation strategies within the SCOR framework delivery phase and blockchain technology integration struggles. Private hospitals encounter obstacles in embracing cutting-edge technologies despite their financial flexibility due to financial constraints and regulations that impede progress in advanced supply chain management practices. The results highlight the importance of acknowledging that while private hospitals may have an edge in adopting technology advancements, there is a lack of research into the lasting impact and scalability of integrating sophisticated Supply Chain Management systems within the private sector long-term effectiveness and risk mitigation strategies are still an underexplored territory in this area Despite offering potential benefits for predicting and adjusting to dynamic demands Deep Reinforcement Learning has not been extensively investigated in hospital environments This is primarily due to concerns over data privacy issues and the shortage of technical expertise which are often insufficiently available, within healthcare organizations In the SCOR frameworks deliver phase highlights a need for better distribution strategies, like involving third party logistics and optimizing logistics to enable responses during crises effectively identified a gap in the system. Although blockchain technology can potentially increase transparency and security in supply chain management (SCM), its utilization in hospital settings is limited due to implementation costs and strict regulations that hinder adoption, especially in hospitals with financial constraints.

5.1. Manager Implication

The findings of this study carry several important managerial implications for healthcare administrators and policymakers aiming to enhance hospital supply chain management (SCM). For private hospitals, the flexibility in funding and operational autonomy presents a unique opportunity to adopt advanced technologies like blockchain and DRL, which can significantly improve SCM efficiency. Investing in predictive analytics and secure data-sharing platforms can strengthen demand forecasting and supply chain resilience. However, these technologies must be scalable and cost-effective to maximize long-term benefits. Additionally, the *delivery* phase of SCM, crucial for the timely and accurate distribution of medical supplies, could be optimized through strategic partnerships with third-party logistics (3PL) providers. Such collaborations and real-time tracking and IoT integration can enhance transparency and responsiveness, especially in crisis situations. Given the regulatory challenges often encountered in private healthcare, managers must also carefully navigate compliance requirements. Collaborating with policymakers to establish flexible guidelines could help accommodate technological innovation without compromising safety and data security. Moreover, as advanced technologies require specialized skills, investment in staff training or hiring technical experts is essential to ensure adequate system management. This focus on technical expertise will support greater efficiency and adaptability in SCM processes over the long term. Finally, integrating sustainable SCM practices, such as Green Supply Chain Management (GSCM), would allow hospitals to align with environmental goals and improve public trust while enhancing supply chain resilience in the face of disruptions.

5.2. Limitation & Future Research

This study's limitations primarily stem from its reliance on secondary literature data, which may not fully capture current or emerging SCM practices in real-world hospital settings. Many reviewed articles concentrate on specific SCM methodologies, potentially introducing a publication bias by excluding studies that utilize alternative approaches. To address this, future research should incorporate primary data collection through case studies, interviews, or surveys with SCM practitioners to capture evolving practices and contextual insights within hospitals. Additionally, the study's focus on general healthcare settings may limit the applicability of its findings to specialized institutions, such as emergency centers, trauma units, or long-term care facilities, where supply chain needs and challenges can differ. Future studies should examine SCM practices within these specialized environments and consider expanding to international settings, as cultural, economic, and regulatory differences can significantly impact SCM in hospitals. As technologies such as AI, IoT, and blockchain continue to advance, research is needed to evaluate their impact on HSCM, particularly in resource-limited environments. Studies exploring these technologies' cost-effectiveness and practical implementation challenges, especially in public hospitals with constrained budgets, would be valuable. Longitudinal studies examining SCM resilience during and after public health crises could identify the most effective long-term practices. Additionally, exploring sustainable SCM practices like GSCM would support both operational and environmental goals, better-aligning hospital SCM with broader sustainability objectives.

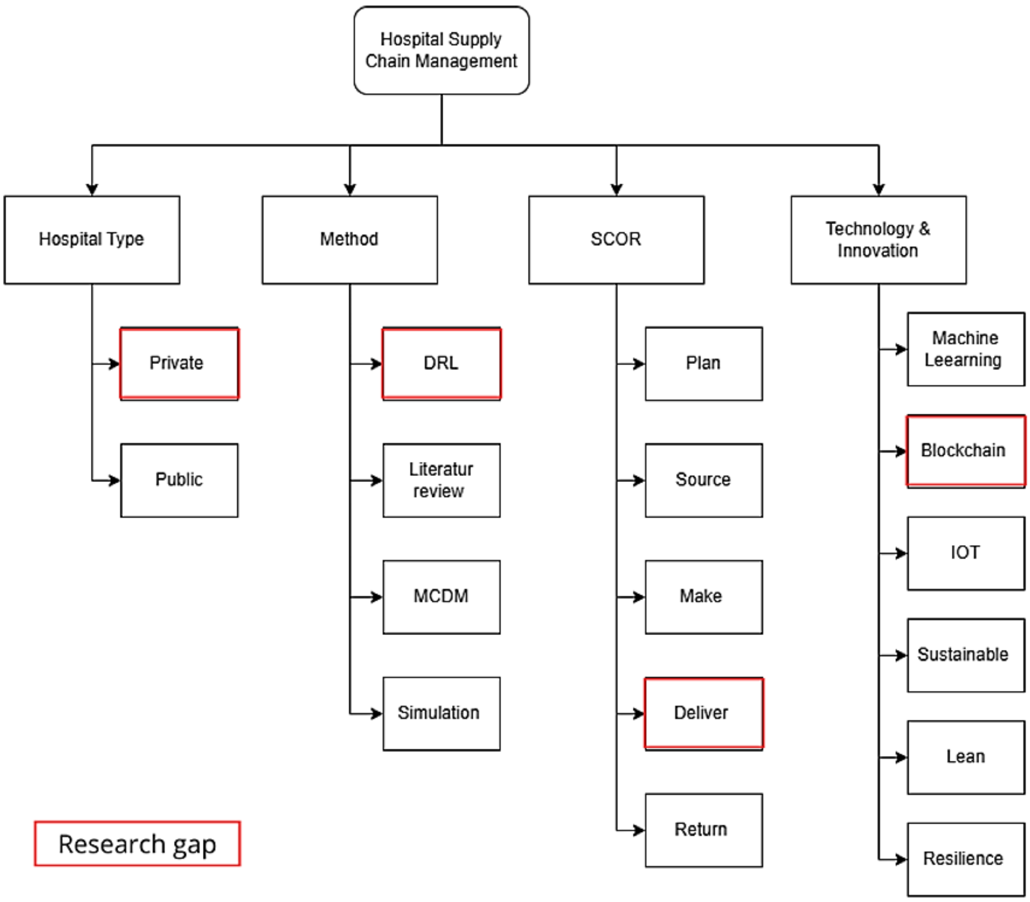

Figure 3. Reviewed categories and research gaps

6. Conclusions

This research systematically reviewed 65 articles on hospital supply chain management (HSCM), identifying four primary research gaps: hospital type, methodologies, the SCOR framework, and technology and innovation. Despite distinguishing between public and private hospitals, limited research addresses the unique supply chain challenges of private hospitals. While private hospitals have the potential to adopt advanced technologies, further studies are needed to explore how they integrate these technologies to optimize supply chain models.

Regarding methodologies, Deep Reinforcement Learning (DRL) shows promise in managing demand fluctuations and complex datasets but is underutilized, with only five studies applying it in HSCM. Given its high technological requirements, future research should focus on developing cost-effective alternatives for broader adoption in healthcare settings with budget constraints.

In the SCOR framework, the "deliver" stage, crucial for timely medical supply delivery, has been overlooked, with only five studies addressing this area. Research focused on improving this stage can enhance hospital flexibility and performance in critical situations. Lastly, while promising transparency and security in hospital supply chains, blockchain technology has seen limited exploration, with only two studies focusing on its application.

Future research should address the gaps identified in hospital supply chain management, particularly in private hospitals, by exploring the integration of advanced technologies like Deep Reinforcement Learning (DRL) and blockchain, especially in the "deliver" stage of the SCOR framework. Given the limited research on private hospitals, studies should investigate how these technologies can enhance the efficiency and resilience of supply chains while ensuring the timely delivery of medical supplies. Additionally, future studies should simplify DRL models for broader applicability in hospitals with budget constraints and explore scalable blockchain solutions to improve security and transparency. By addressing these gaps, future research can contribute to more efficient, resilient, and responsive hospital supply chains, ultimately improving patient care outcomes.

References

Ahtiainen, H. K., Kallio, M. M., Airaksinen, M., & Holmström, A. R. (2020). Safety, time and cost evaluation of automated and semi-automated drug distribution systems in hospitals: A systematic review. *European Journal of Hospital Pharmacy, 27*(5), 253–262. doi:10.1136/ejhpharm-2018-001791

Al Moteri, M., & Alojail, M. (2023). Factors influencing the supply chain management in e-health using UTAUT model. *Electronic Research Archive, 31*(5), 2855–2877. doi:10.3934/ERA.2023144

Albrakat, N. S. A., Al-Hawary, S. I. S., & Muflih, S. M. (2023). Green supply chain practices and their effects on operational performance: An experi-mental study in Jordanian private hospitals. *Uncertain Supply Chain Management, 11*(2), 523–532. doi:10.5267/j.uscm.2023.2.012

Allahham, M., Sharabati, A. A. A., Hatamlah, H., Ahmad, A. Y. B., Sabra, S., & Daoud, M. K. (2023). Big Data analytics and AI for green supply chain integration and sustainability in hospitals. *WSEAS Transactions on Environment and Development, 19*, 1218–1230. doi:10.37394/232015.2023.19.111

Al-Nawafah, S. S., Al-Shorman, H. M., Aityassine, F. L. Y., Khrisat, F. A., Hunitie, M. F. A., Mohammad, A., & Al-Hawary, S. I. S. (2022). The effect of supply chain management through social media on competitiveness of the private hospitals in Jordan. *Uncertain Supply Chain Management, 10*(3), 737–746. doi:10.5267/j.uscm.2022.5.001

Beaulieu, M., & Bentahar, O. (2021). Digitalization of the healthcare supply chain: A roadmap to generate benefits and effectively support healthcare delivery. *Technological Forecasting and Social Change, 167*. doi:10.1016/j.techfore.2021.120717

Bialas, C., Bechtsis, D., Aivazidou, E., Achillas, C., & Aidonis, D. (2023). A holistic view on the adoption and cost-effectiveness of technology-driven supply chain management practices in healthcare. *Sustainability (Switzerland), 15*(6). doi:10.3390/su15065541

Bø, E., Hovi, I. B., & Pinchasik, D. R. (2023). COVID-19 disruptions and Norwegian food and pharmaceutical supply chains: Insights into supply chain risk management, resilience, and reliability. *Sustainable Futures, 5*. doi:10.1016/j.sftr.2022.100102

Buttigieg, S. C., B. F., X. A., & D. P. K. (2020). Healthcare supply chain management: Application in the Maltese healthcare system.

Bvuchete, M., Grobbelaar, S. S., & van Eeden, J. (2021). A network maturity mapping tool for demand-driven supply chain management: A case for the public healthcare sector. *Sustainability (Switzerland), 13*(21). doi:10.3390/su132111988

Chen, D., & Wanbon, R. (2023). Disaster preparedness: Hospital pharmacy strategy for prioritized inventory management and drug procurement on Vancouver Island. *Disaster Medicine and Public Health Preparedness, 17*(2). doi:10.1017/dmp.2022.186

Chiang, C., & Chuang, M. C. (2024). Effect of sustainable supply chain management on procure-ment environmental performance: A perspective on resource dependence theory. *Sustainability (Switzerland), 16*(2). doi:10.3390/su16020586

Ding, B., Yang, X., Gao, T., Liu, Z., & Sun, Q. (2024). Confirmation of a measurement model for hospital supply chain resilience. *Frontiers in Public*

Health, 12. doi:10.3389/fpubh.2024.1369391

Dorgham, K., Nouaouri, I., Nicolas, J. C., & Goncalves, G. (2022). Collaborative hospital supply chain network design problem under uncertainty. *Operational Research, 22*(5), 4607–4640. doi:10.1007/s12351-022-00724-y

Duque-Uribe, V., Sarache, W., & Gutiérrez, E. V. (2019). Sustainable supply chain management practices and sustainable performance in hospitals: A systematic review and integrative framework. *Sustainability (Switzerland), 11*(21). doi:10.3390/su11215949

El-Garaihy, W. H., Badawi, U. A., Seddik, W. A. S., & Torky, M. S. (2022). Design, building and validating a measuring scale for the supply chain management practices of industrial organizations by assessing their efficiency on SCM measures. *Uncertain Supply Chain Management, 10*(1), 49–68. doi:10.5267/j.uscm.2021.10.010

Emadi, P., & Pasek, Z. J. (2020). Blood shortage management with a reactive lateral transshipment approach in a local blood supply chain.

George, S., & Elrashid, S. (2023). Inventory management and pharmaceutical supply chain performance of hospital pharmacies in Bahrain: A structural equation modeling approach. *SAGE Open, 13*(1). doi:10.1177/21582440221149717

Holm, M. R., Rudis, M. I., & Wilson, J. W. (2015). Medication supply chain management through implementation of a hospital pharmacy computerized inventory program in Haiti. *Global Health Action, 8*(1). doi:10.3402/gha.v8.26546

Hu, H., Xu, J., Liu, M., & Lim, M. K. (2023). Vaccine supply chain management: An intelligent system utilizing blockchain, IoT and machine learning. *Journal of Business Research, 156.* doi:10.1016/j.jbusres.2022.113480

Improta, G., Scala, A., Trunfio, T. A., & Guizzi, G. (2021). Application of supply chain management at drugs flow in an Italian hospital district. *Journal of Physics: Conference Series, 1828*(1). doi:10.1088/1742-6596/1828/1/012081

Islam, S., & Habib, Md. M. (2024). Integrating forecasting & planning management for sustainable hospital supply chains and societal advancement. *International Journal of Supply Chain Management, 13*(4), 34–41. doi:10.59160/ijscm.v13i4.6263

Islam, S., Habib, Md. M., & Islam, G. M. N. (2023). A study on sustainable hospital supply chain management towards societal advancement in the post-pandemic era. *International Journal of Supply Chain Management, 12*(4), 36–42. doi:10.59160/ijscm.v12i4.6201

Ivanov, D., & Dolgui, A. (2022). The shortage economy and its implications for supply chain and operations management. *International Journal of Production Research, 60*(24), 7141–7154. doi:10.1080/00207543.2022.2118889

Jamil, F., Hang, L., Kim, K. H., & Kim, D. H. (2019). A novel medical blockchain model for drug supply chain integrity management in a smart hospital. *Electronics (Switzerland), 8*(5). doi:10.3390/electronics8050505

Jifar, W. W., Geneti, G. B., & Dinssa, S. D. (2022). The impact of COVID-19 on pharmaceutical shortages and supply disruptions for non-communicable diseases among public hospitals of South West, Oromia, Ethiopia. *Journal of Multidisciplinary Healthcare, 15,* 1933–1943. doi:10.2147/JMDH.S377319

Kachwee, M., & Hartmann, M. D. (2013). Hospital supply chain management and optimisation. *Vol. 9,* 511-512.

Karbassi Yazdi, A., Wanke, P., Ghandvar, M., Hajili, M., & Mehdikarami, M. (2022). Implementation of sustainable supply chain management considering barriers and hybrid multiple-criteria decision analysis in the healthcare industry. *Mathematical Problems in Engineering, 2022*. doi:10.1155/2022/8221486

Khot, U. N. (2020). Navigating healthcare supply shortages during the COVID-19 pandemic: A cardiologist's perspective. *Circulation: Cardiovascular Quality and Outcomes, 13*(6), E006801. doi:10.1161/CIRCOUTCOMES.120.006801

Kochakkashani, F., Kayvanfar, V., & Haji, A. (2023). Supply chain planning of vaccine and pharmaceutical clusters under uncertainty: The case of COVID-19. *Socio-Economic Planning Sciences, 87*. doi:10.1016/j.seps.2023.101602

Kwan, W. M., Mok, C. K., Kwok, Y. T., Lam, H. W., Chan, K. H., Law, T. H. S., Leung, P. M., Mak, M. Y., Que, T. L., & Tang, Y. H. (2020). Bundled interventions for consumption management and monitoring of personal protective equipment in COVID-19 pandemic in Hong Kong local hospitals. *BMJ Open Quality, 9*(4). doi:10.1136/bmjoq-2020-000990

Latonen, S. H., Suominen, R. M., Juppo, A. M., Airaksinen, M., & Seeck, H. (2023). Organisation of cross-sector collaboration and its influence on crisis management effectiveness among pharmaceutical supply chain stakeholders during the COVID-19 pandemic. *Public Health, 222*, 196–204. doi:10.1016/j.puhe.2023.06.042

Lau, Y. Y., Dulebenets, M. A., Yip, H. T., & Tang, Y. M. (2022). Healthcare supply chain management under COVID-19 settings: The existing practices in Hong Kong and the United States. *Healthcare (Switzerland), 10*(8). doi:10.3390/healthcare10081549

Leaven, L., & Ahmmad, K. (2017). Inventory management applications for healthcare supply chains. Retrieved from https://www.researchgate.net/publication/320417495

Li, X., & Martins, A. L. (2024). Leagility in the healthcare research: A systematic review. *BMC Health Services Research, 24*(1). doi:10.1186/s12913-024-10771-0

Liu, W., Zhang, W., Dutta, B., Wu, Z., & Goh, M. (2020). Digital twinning for productivity improvement opportunities with robotic process automation: Case of greenfield hospital. *International Journal of Mechanical Engineering and Robotics Research, 9*(2), 258–263.https://doi.org/10.18178/ijmerr.9.2.258-263

Lotfi, R., Kargar, B., Rajabzadeh, M., Hesabi, F., & Özceylan, E. (2022). Hybrid fuzzy and data-driven robust optimization for resilience and sustainable health care supply chain with vendor-managed inventory approach. *International Journal of Fuzzy Systems, 24*(2), 1216–1231.. https://doi.org/10.1007/s40815-021-01209-4

Marques, L., Martins, M., & Araújo, C. (2020). The healthcare supply network: Current state of the literature and research opportunities. *Production Planning and Control, 31*(7), 590–609. https://doi.org/10.1080/09537287.2019.1663451

Martín-Blanco, C., Zamorano, M., Lizárraga, C., & Molina-Moreno, V. (2022). The impact of COVID-19 on the sustainable development goals: Achievements and expectations. *International Journal of Environmental Research and Public Health, 19*(23). https://doi.org/10.3390/ijerph192316266

Mirghafoori, S. H., Sharifabadi, A. M., & Takalo, S. K. (2018). Development of causal model of sustainable hospital supply chain management using the intuitionistic fuzzy cognitive map (IFCM) method. *Journal of Industrial Engineering and Management, 11*(3), 588–605. https://doi.org/10.3926/jiem.2517

Mittal, A., & Mantri, A. (2023). A literature survey on healthcare supply chain management. *F1000Research, 12*, 759. https://doi.org/10.12688/f1000research.131440.1

Modisakeng, C., Matlala, M., Godman, B., & Meyer, J. C. (2020). Medicine shortages and challenges with the procurement process among public sector hospitals in South Africa; Findings and implications. *BMC Health Services Research, 20*(1). https://doi.org/10.1186/s12913-020-05080-1

Nabelsi, V., & Gagnon, S. (2017). Information technology strategy for a patient-oriented, lean, and agile integration of hospital pharmacy and medical equipment supply chains. *International Journal of Production Research, 55*(14), 3929–3945. https://doi.org/10.1080/00207543.2016.1218082

Neve, B. v., & Schmidt, C. P. (2022). Point-of-use hospital inventory management with inaccurate usage capture. *Health Care Management Science, 25*(1), 126–145. https://doi.org/10.1007/s10729-021-09573-1

Nouranian, M., Saghaeiannejad Isfahani, S., & Memarzadeh, H. (2021). Information sharing and information quality in the drugs and medical consumables supply chain management (SCM). *Iranian Journal of Pharmaceutical Sciences, 2021*(1). www.ijps.irOriginalArticle

O'Mahony, L., McCarthy, K., O'Donoghue, J., Teeling, S. P., Ward, M., & McNamara, M. (2021). Using lean six sigma to redesign the supply chain to the operating room department of a private hospital to reduce associated costs and release nursing time to care. *International Journal of Environmental Research and Public Health, 18*(21). https://doi.org/10.3390/ijerph182111011

Pamucar, D., Torkayesh, A. E., & Biswas, S. (2023). Supplier selection in healthcare supply chain management during the COVID-19 pandemic: A novel fuzzy rough decision-making approach. *Annals of Operations Research, 328*(1), 977–1019. https://doi.org/10.1007/s10479-022-04529-2

Pratono, A. H., & Maharani, A. (2023). Enhancing global supply chain resilience in the Indonesian medical device industry: A dynamic capability perspective. *Journal of Asia Business Studies*. https://doi.org/10.1108/JABS-03-2022-0081

Sakly, H., Said, M., & Tagina, M. (2021). Healthcare supply chain management: Towards 3D MRI aorta model with CPU-GPU parallel architecture for medical manufacture. *Cogent Medicine, 8*(1). https://doi.org/10.1080/2331205x.2021.2012888

Setiawati, M., Pasaribu, A., Halim, D. P., & Darmawan, J. (2023a). Exploring hospital supply chain partnership factors and its impact on overall supply chain performance. *Petra International Journal of Business Studies, 6*(2), 213–225. https://doi.org/10.9744/petraijbs.6.2.213-225

Setiawati, M., Pasaribu, A., Halim, D. P., & Darmawan, J. (2023b). Exploring hospital supply chain partnership factors and its impact on overall supply chain performance. *Petra International Journal of Business Studies, 6*(2), 213–225. https://doi.org/10.9744/petraijbs.6.2.213-225

Setiawati, M., Simatupang, M., & Okdinawati, L. (2024). Partner in hospital supply chain management: A systematic literature review. *International Journal of Applied Business Research,* *2024*(2), 136–151. https://doi.org/10.35313/ijabr.v6i02.362

Setyaningrum, R., & Muafi, M. (2023). Green human resource management, green supply chain management, green lifestyle: Their effect on business sustainability mediated by digital skills. *Journal of Industrial Engineering and Manage-ment, 16*(1), 1–26. https://doi.org/10.3926/jiem.4152

Shahbahrami, E., Kalhor, R., Amerzadeh, M., Hasani, M., & Kiani, M. (2024). A dynamic management model for sustainable drug supply chain in hospital pharmacies in Iran. *BMC Health Services Research, 24*(1). https://doi.org/10.1186/s12913-024-11692-8

Shen, J., Bu, F., Ye, Z., Zhang, M., Ma, Q., Yan, J., & Huang, T. (2024). Management of drug supply chain information based on "artificial intelligence + vendor managed inventory" in China: Perspective based on a case study. *Frontiers in Pharmacology, 15*. https://doi.org/10.3389/fphar.2024.1373642

Shih, H., & Rajendran, S. (2020). Stochastic inventory model for minimizing blood shortage and outdating in a blood supply chain under supply and demand uncertainty. *Journal of Healthcare Engineering, 2020*. https://doi.org/10.1155/2020/8881751

Shokouhifar, M., & Ranjbarimesan, M. (2022). Multivariate time-series blood donation/demand forecasting for resilient supply chain management during COVID-19 pandemic. *Cleaner Logistics and Supply Chain, 5*. https://doi.org/10.1016/j.clscn.2022.100078

Sienkiewicz-Małyjurek, K., & Szymczak, M. (2024). Understanding public service supply chain management: A systematic literature review. *Management Review Quarterly, 74*(3), 1879–1943. https://doi.org/10.1007/s11301-023-00350-8

Socal, M. P., Sharfstein, J. M., & Greene, J. A. (2021). The pandemic and the supply chain: Gaps in pharmaceutical production and distribution. https://www.accessdata.fda.gov/scripts/drug-shortages/default.cfm

Spieske, A., Gebhardt, M., Kopyto, M., & Birkel, H. (2022). Improving resilience of the healthcare supply chain in a pandemic: Evidence from Europe during the COVID-19 crisis. *Journal of Purchasing and Supply Management, 28*(5). https://doi.org/10.1016/j.pursup.2022.100748

Sporrong, S. K., Traulsen, J. M., Damene Kabtimer, W., Mekasha Habtegiorgis, B., Gebregeorgise, D. T., Essah, N., & Brown, A. N. (2016). Developing and sustaining human resources in the health supply chain in Ethiopia: Barriers and enablers. https://doi.org/10.3316/informit.204534144127713

Tatiana, E., Orjuela, R., Rincón-Guevara, O., & Jaimes, W. A. (2023). Hospital supply chain management: Cross-disciplinarity opportunities in the post-pandemic era and research agenda. *Operations and Supply Chain Management, 16*(1), 47–61.

Uthayakumar, R., & Priyan, S. (2013). Pharmaceutical supply chain and inventory management strategies: Optimization for a pharmaceutical company and a hospital. *Operations Research for Health Care, 2*(3), 52–64. https://doi.org/10.1016/j.orhc.2013.08.001

Yu, Z. (2023). Optimizing internal control in public hospital supply chain: A game theory-based approach. *Frontiers in Public Health, 11*. https://doi.org/10.3389/fpubh.2023.1240757

Ziat, A., Sefiani, N., Azzouzi, H., & Reklaoui, K. (2024). A generic sustainable performance management system for hospital supply chain: Design & analysis. *Health Systems, 13*(2), 97–108. https://doi.org/10.1080/20476965.2022.2155256

Ziat, A., Sefiani, N., Reklaoui, K., & Azzouzi, H. (2020). A generic framework for hospital supply chain. *International Journal of Healthcare Management, 13*(S1), 488–495. https://doi.org/10.1080/20479700.2019.1603415

Zwaida, T. A., Pham, C., & Beauregard, Y. (2021). Optimization of inventory management to prevent drug shortages in the hospital supply chain. *Applied Sciences (Switzerland), 11*(6). https://doi.org/10.3390/app11062726