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Original Article

Technology-Enabled Logistics Management in Healthcare Systems: A Systematic Review

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Abstract

Background *:Healthcare logistics has undergone rapid technological transformation as digital, automated, and data-intensive tools widely used in tracking, and coordination of medical commodities, information, and services. Despite rapid acceleration of technology-enabled logistic concepts and shift in patient care modalities, existing reviews often focus on isolated technologies; such as AI, blockchain or automation without synthesizing how these tools shape logistics performance across diverse health-system contexts. This review therefore aimed to synthesize current evidence on technology-enabled logistics and articulates how these tools influence operational efficiency, supply chain transparency, responsiveness and continuity of care.*

Methods*: A systematic search of PubMed, Scopus, Embase, Web of Science, and grey literature sources (Jan 2010–Dec 2022) identified 3,367 database records and 17 grey literature entries. The screening was conducted by two reviewers, and yielded 140 articles. An inductive thematic synthesis approach was used.*

Results: *Five themes were found from the synthesis of this review: digital supply chain systems, advanced technological applications, artificial intelligence, remote monitoring and care logistics, and secure digital data-sharing among supply chain actors. Across these domains, technology-enabled logistics tools found to be consistently improved inventory management, improved traceability, enhanced documentation quality and increased coordination across facilities.*

Conclusions: *Technology-enabled logistics systems are gaining attention to improve healthcare operations. This system bringing measurable gains in efficiency and thus, service quality. However, interoperability challenges, workforce readiness, and regulatory issues continue to impede adoption. Examining contextual feasibility and the socio-technical factors that determine whether these innovations translate into sustainable and equitable improvements can be future research agenda.*

Key words: *Healthcare logistics, technology-enabled logistics, supply chain management, automation, digitalization, artificial intelligence*

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Introduction

The logistics management concept has gained attention in the healthcare industry(1), and becoming a pivotal operational and quality improvement tool. Today's health systems confront rising delivery costs(2), unpredictable demand patterns, growing therapeutic complexity, and efficiency gains expanding adoption patterns across different geographic regions(3, 4). The pressure to ensure reliable, efficient, and clinically responsive flows of medicines, equipment, diagnostics, and information has accelerated the integration of digital and automated solutions(5).

Although a growing body of literature documents how specific technologies; such as AI algorithms, blockchain architectures, IoT-enabled tracking devices, and remote monitoring systems, are being applied to logistics challenges, this evidence remains fragmented(6). What is lacking is a unifying synthesis that clarifies the conceptual boundaries of technology-enabled logistics, defines the constituent technological categories, and integrates evidence across health-system contexts, including low-resource environments where logistical vulnerabilities are most pronounced.

Technological Integration in Healthcare Logistics

Integrating advanced technologies into healthcare logistics has significantly improving efficiency, accuracy, and patient care(7). Technologies like the Internet of Things (IoT), blockchain, and cloud computing have been pivotal in transforming logistics management(7). IoT devices enable real-time tracking and monitoring of medical supplies and equipment to ensure that critical items are always available and at their optimal quality. Blockchain technology enhances the security and transparency of data sharing among healthcare providers, suppliers, and patients, reducing the risk of errors and data security issues(7, 8). Cloud computing facilitates big data storage and access, enabling healthcare organizations to analyze and optimize their logistics operations more effectively(7).

Impact of Artificial Intelligence on Logistics Efficiency

Artificial Intelligence (AI) has emerged as a game-changer in healthcare logistics, offering predictive analytics, automation, and decision support systems that significantly enhance operational efficiency(9). Artificial Intelligence (AI) is increasingly reshaping the way healthcare systems handle their logistics, not just by automating tasks but by offering a clearer sense of what's coming next based on .AI algorithms that can predict demand for medical supplies based on historical data, helping to prevent stockouts and overstock situations(10). Automation powered by AI reduces the need for manual intervention in logistics processes, minimizing human errors and speeding up tasks such as inventory management and order processing(10). Furthermore, decision support tools built on AI go a step further, giving managers concrete insights when they're weighing options around purchasing, distribution routes, or how best to allocate limited resources(11). This kind of forecasting helps avoid both empty shelves and unnecessary stockpiles, lower costs, and, ultimately, better patient care.

Remote Monitoring and Care

Remote monitoring and care have become essential components of modern healthcare, especially with the rise of infectious disease outbreaks and chronic non-communicable diseases(12). Telemedicine platforms, remote diagnostic tools, and wearable health devices allow healthcare providers to monitor patients' conditions and deliver care without needing physical visits and also empower the patient to monitor their own health conditions(13). This shift reduces the burden on healthcare facilities and ensures continuous care for patients and relieves financial pressure from repeated hospital visits, particularly those in remote or underserved areas(12). Remote care only works if the right devices, medications, and support supplies available where and when they're needed. Effective logistics, timely deliveries, stable supply chains, and sustainable distribution systems are crucial to support their care at home(14).

Future prospects and global trends of health care logistics

The future of healthcare logistics looks promising, with ongoing technological advancements and increasing global adoption of logistics management practices In many high-income regions, the conversation has shifted from simply adopting these tools to figuring out how to weave them smoothly into long-established healthcare infrastructures(15). Meanwhile, low- and middle-income countries are rapidly discovering how transformative these systems can be, often using them to overcome long-standing gaps in access, distribution, and coordination(16). Globally, the push toward digitalization and automation shows forwarding steps. Health systems everywhere are under pressure to deliver care that is faster, more affordable, and more attuned to patient needs, and modern logistics platforms offer a clear path toward that goal(17).. As these technologies continue to advance, we can expect an even wider range of intelligent, adaptive logistics solutions to emerge, raising both the quality and reach of healthcare services across diverse(17, 18).

Recently, various impressive literature reviews have been conducted on healthcare logistics management. The common ones were the application of logistics management concepts as performance measures for hospitals (19), healthcare facilities maintenance management(20), hospital's material logistics(21), technological application in inventory management(22), information management, and warehouse technology (23), Lean, Agile, and Leagile practices and tools applied to healthcare (24), Decision-Making Models for Healthcare Supply Chain(25) and (26) focused logistic activities related to medical waste management. However, the scope of emerging technology utilization and trends in logistics applications and technologies adaptable to low-resource settings have not been well-documented.

This systematic review aims to identify and synthesize key advancements in technology-enabled healthcare logistics, categorized into five main themes: supply chain management, technological tools applications, artificial intelligence (AI), remote monitoring and care, and secure data sharing. This offers valuable insights into the current state of the discipline and the possible adoption of emerging technologies within the healthcare industry. This data will provide insights for policymakers at the Federal Ministry of Health and logistic strategists, as it will help them in making informed decisions and considering contextual attributes before investing in cutting-edge technologies. Moreover, by combining the existing evidence and proposing future research paths, this review could contribute to the progression of healthcare logistics management theories and practical implementations.

Definitions of Key Concepts

Technology-enabled logistics

Technology-enabled logistics is the coordinated use of digital, automated, and data-driven systems to enable the smooth flow of materials and information across healthcare delivery networks(27). These systems embed algorithmic intelligence, sensor-driven visibility, and real-time data exchange for timely decisions(28). This system influence logistics performance and enables forecasting, transport optimization, traceability, and temperature monitoring. Examples include IoT sensor networks for cold-chain integrity, automated replenishment systems, and AI-supported demand forecasting models(27, 28).

Technology-supported logistics
This term represents information systems and digital tools that enhance logistics process through improved documentation, communication, and administrative coordination (29). Examples include electronic logistics management information systems (LMIS), digital requisition platforms, and electronic health records when used to streamline supply-related decision-making(29, 30).

Digital supply chain systems
Digital supply chain systems are the integrated platforms that connect suppliers, distributors, healthcare facilities, and regulatory entities through interoperable and real-time data (31). These systems incorporate different functions across the supply chain process, such as digital ordering, automated stock visibility, shipment tracking, and performance analysis to ensure reliability of supplies (31, 32).

Advanced technological applications
Advanced technological applications refer to high-capability digital innovations that introduce algorithmic, robotic, or cyber-physical enhancements to logistics operations(33). These systems leverage machine learning, automation, robotics, or augmented sensing to optimize routing, automate storage and retrieval, manage environmental conditions, and support predictive analytics(34) that transforms governance structure and bring maximum efficiency(33). Robotic dispensing units, automated guided vehicles, machine-learning models for pharmaceutical demand forecasting, and smart packaging equipped with environmental sensors are among the developments in healthcare settings(35).

Secure digital data-sharing mechanisms
Secure digital data-sharing mechanisms comprise systems designed to protect the confidentiality, integrity, of logistics data. These mechanisms operate through encryption, distributed ledger technologies (e.g., blockchain) and access authentication protocols that prevent unauthorized access or data breach(36). Their defining mechanism is the establishment of trust in digital exchanges, especially when logistics workflows involve multiple actors in blockchain-based drug-traceability networks and encrypted platforms used for monitoring high-value medical supplies(36, 37).

Hence, these definitions clarify the conceptual landscape in which modern healthcare logistics operates and describes the criteria used to determine study eligibility in this review. This foundation also creates terminological precision for synthesizing the highly heterogeneous evidence base of the logistics management concepts.

To guide the present review, we articulated three PICO-aligned research questions:

A, How are digital, automated, and data-driven technologies applied across healthcare logistics workflows?

B, What impacts do these technologies have on logistics efficiency, accuracy, transparency, coordination, and clinical responsiveness?

C, Which contextual, infrastructural, regulatory, and organizational factors enable or impede their adoption across diverse health-system settings, particularly in low-resource environments?

Therefore, by combining evidence across these domains, this review aims to reveal the operational, organizational, and contextual implications of technological innovation in healthcare logistics.

Methods

General overview

This systematic review was aimed to understand the current landscape of technology-enabled logistics within healthcare systems and also to synthesize advancements and contextual issues of the tools beyond isolated technological adoption. Therefore, the methodological scope of this review extends beyond a case example and reflects an intentional integration of health-informatics rigor, logistics-systems theory, and evidence-synthesis standards. PRISMA 2020 guidelines was used in this review to ensure transparency, replicability, and methodological depth.

Protocol registration

The review protocol was prospectively registered in PROSPERO (CRD42023437094). This provide a time-stamped methodological approach with clear research objectives, eligibility criteria, screening roles, and planned synthesis procedures that mitigate post screening modification bias.

Search strategy and data bases
A comprehensive search was carried out across four major scientific databases; PubMed, Scopus, Embase, and Web of Science, to identify peer-reviewed studies published between January 2010 and December 2022. This time span was selected to encompass the decade during which adoption of digital tools accelerated within global health logistics ecosystems and also to understand the trends and focuses in these developments. Search terms

were adjusted to emphasize digital, automated, or technological logistics concepts applied to healthcare system to ensure consistency with the review scope and predefine SPICE framework. Our search strings combined Boolean logic with controlled vocabulary (e.g., MeSH terms), enabling high-granularity retrieval across technological concepts such as "healthcare logistics," "healthcare logistics management," "hospital logistics," "supply chain management," "automation," "optimization," "digitalization," "inventory modeling," "decision support tools," "IoT," "blockchain," "AI," and "remote monitoring." (Full search strategy is included in Annex 1 and Annex 2.).

Grey literature search strategy
To minimize publication bias, we executed grey-literature search encompassing: Google Scholar, digital-health conference proceedings, international health-supply-chain reports (WHO, UNICEF, Global Fund), and university digital dissertations. This search yielded seventeen grey-literature

Table 1. Outline of the SPICE framework used in the search approach

Setting	Healthcare
Perspective	How is logistics conceptualized and applied from the perspective of healthcare?
Interest/phenomenon	What is the extent of health logistics application?
Comparison	Compare with the traditional approach
Evaluation	In relation to operational efficiency
Inclusion criteria	Original articles that included keywords (healthcare logistics management/ automation/ digitalization/ optimization/ Medical logistics/hospital logistics/ supply chain management/simulation/) in the title/abstract/ keywords, published in English.
Exclusion	Duplication, review, letters to editorial, full text not available, insufficient detail on outcome, and articles published in languages other than English.

Inclusion Criteria
Our inclusion criteria clearly set that studies were eligible if they focus on a technological component directly influencing logistics processes in the healthcare settings (e.g., tracking, forecasting, storage, distribution, data transmission); and also **f**ocused on healthcare delivery systems**,** including hospitals, supply chains, clinical logistics units; published in English to maintain methodological consistency; used empirical, modeling, or implementation science, including simulations, pilots, or mixed-methods approaches and full texts were available to evaluate for eligibility.

Exclusion Criteria
we excluded when the studies did not incorporate a digital, automated, or technologies directly relevant to logistics functions in the healthcare system. We also removed papers that focused solely on administrative information systems with no operational bearing on supply chain activities. In addition, non-primary sources, such as reviews, commentaries, protocols, editorials, and conference abstracts, were not considered in this review. Finally, studies were excluded if the full text was unavailable or if they were published in languages other than English.

Screening and Study Selection Process
All records were imported into EndNote 20.1 for deduplication clearance and a dual-screening strategy was adopted. In first stage title and abstract Screening was done by two independent reviewers. Disagreements were resolved through discussion. At stage two full-Text assessment was conducted by the same two reviewers.

Screening Outcomes
Of 3,367 database records and 17 grey-literature sources, 140 studies met all eligibility criteria. The detailed PRISMA flow diagram (Figure 2) depicts each phase of the screening process.

Data extraction, synthesis, and analysis
The data extraction template was prepared in Microsoft Excel. Two authors (MN and GG) independently extracted data; discrepancies were reexamined collaboratively to produce a unified dataset, and a third author (YD) reviewed the data for consistency. A broad range of information were extracted from each study to support a structured synthesis of this review beyond the mere technological adoption. Particularly, the year of publication, country, and type of healthcare setting, as well as the specific technological approach examined, whether IoT devices, artificial intelligence tools, blockchain-based systems, automation technologies, or other digital solutions were the publication details focused during extraction process. We also recorded the logistics functions addressed by the researchers, the nature of the data architecture and any interoperability features described in

Figure 1. A word cloud from search strings

the study, and the stage of implementation, ranging from simulations and pilot tests to fully scaled deployments to clearly understand the trend. In addition, we captured both quantitative and qualitative outcomes, along with any factors identified by the authors as facilitators, barriers, or broader contextual influences shaping the technology's performance in the healthcare contexts.

Synthesis Approach

This systematic review was assessed broader concepts of technology-enabled logistics contextualized to healthcare systems. Because of heterogeneity of technologies, contexts, and study designs, meta-analysis was not feasible. We therefore adopted an inductive thematic synthesis approach with systematically designed analytic technique. The synthesis included initial coding of all extracted data to identify recurring conceptual patterns; searching for themes from the codes which linked to technological features, logistics functions, and operational challenges, where two coders independently refined the codebook before merging. We revised the theme to ensure coherency and defining the theme leading to the five thematic categories used in this review and mapping themes to conceptual frameworks, including SCOR (logistics operations) to analyzes logistics processes, Unified Theory of Acceptance and Use of Technology (UTAUT) (to assess technology adoption), and information-logistics theory to assess the role of improved information accuracy for better logistics performance.

Results

Study selection process and findings

At the initial screening process, we retrieved 3,367 articles from the four databases (PubMed: 1,987; Scopus: 567; Embase: 571; Web of Science: 242). After removing duplicates using Endnote 20.1, 3,200 articles remained. Next, screening the studies by title and abstract excluded 592 and 1,254 articles, respectively, leaving 1,354 for full-text review. Of these, 136 met the inclusion criteria. From the grey literature search, an additional 17 records were identified and four of them found eligible for inclusion. Based on the objective of the review and predefined criteria, only studies incorporating digital, automated, or technology supported logistics tools were retained and analyzed. Following PRISMA 2020 reporting standards, a total of 140 studies were included in the final synthesis (Figure 2) and a completed PRISMA 2020 checklist accompanies this review to support transparency in reporting (Annex 4).

Overview of descriptive analysis

Across the 140 studies included in this review, the evidence reflected a wide geographic and operational spread, covering Latin America, the USA, Europe, Asia, the Middle East, and Africa and a broad healthcare environments and contexts, from tertiary hospitals to primary care networks, diagnostic laboratories, and humanitarian supply chains. The technologies assessed in this review varied in their stage of maturity. Some addressed

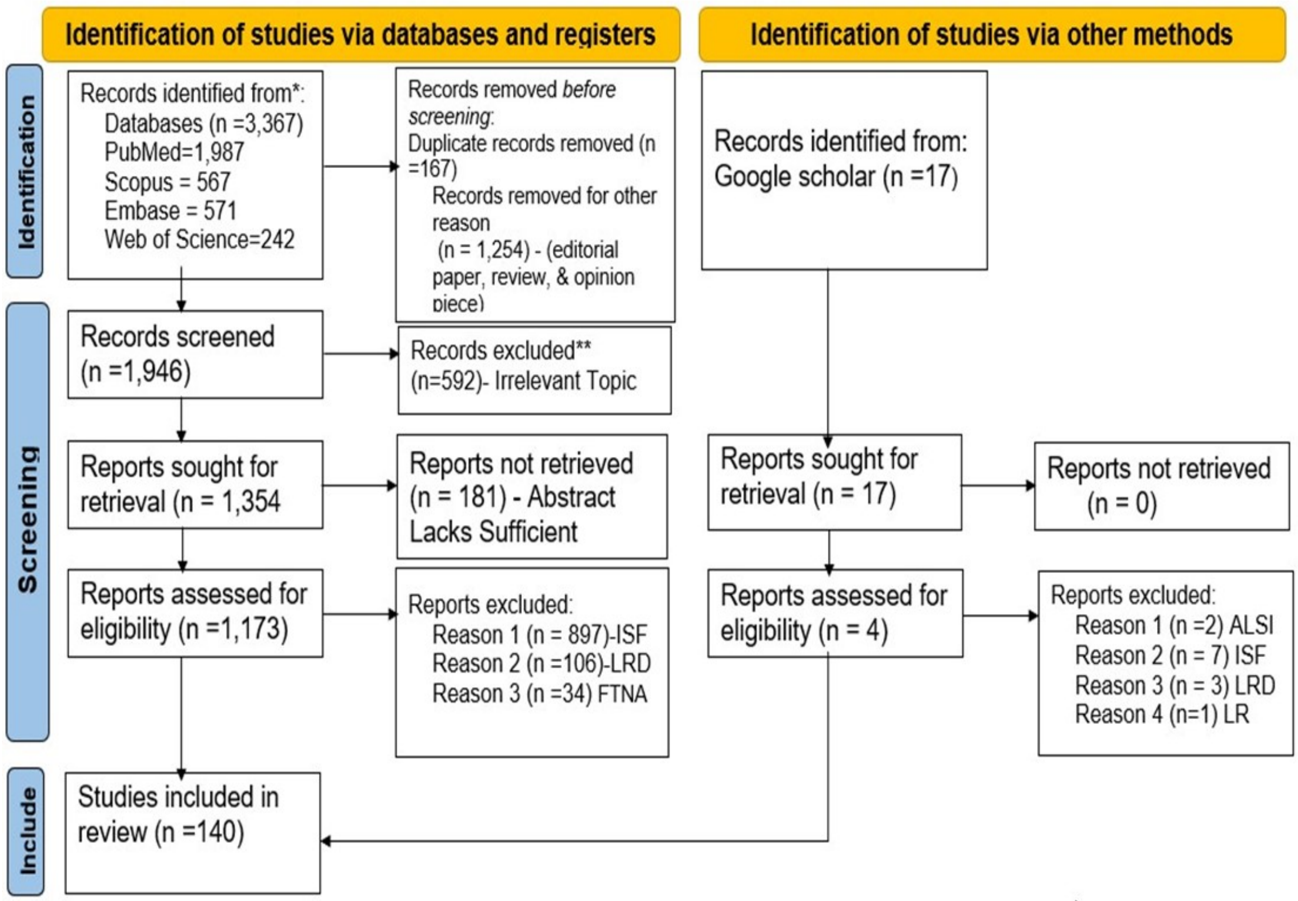

Figure 2 PRISMA 2020 flow diagram

only as conceptual or early prototyping efforts, while others were embedded in routine operations and had reached large-scale implementation.

Additionally, the types of evidence included in the review revealed variation. Approximately one-third of the studies examined technologies that had been introduced and tested in everyday practice, giving insight into how these systems perform under real operational pressures. Close to half, however, were built around simulation and computational modelling, reflecting the early developmental stage of many digital logistics tools. The remaining combined observational data with modelling or qualitative methods. Usually, this observed pattern points to an uneven path of technological maturity: robotics and automated systems are still confined to experimental or small-scale pilot work, whereas digital dashboards, IoT-based monitoring devices, and systems designed to track product integrity have moved much further along the implementation pathway and are being used across a wide range of healthcare settings (Figure 3).

Accordingly, the synthesis of these evidence yielded technological applications in a past decade included blockchain-based supply verification, Internet of Things (IoT) tracking tools (38-42);,RFID use in inventory systems, robotics and automation (43-46), artificial intelligence (AI) decision-support tools, and telehealth supported logistics functions(47-51) were the most common tools shaped the global healthcare systems with uneven distribution inclined to resources and digital infrastructures**.** Figure 4 illustrates a continued rise in publications related to technology-enabled logistics optimization, particularly after 2015, corresponding with increased global investment in digital health ecosystems.

Thematic findings
The inductive analysis yielded five major technology -driven themes, each representing a core element of modern healthcare logistics management approaches and describe how these tools reshape healthcare logistics.

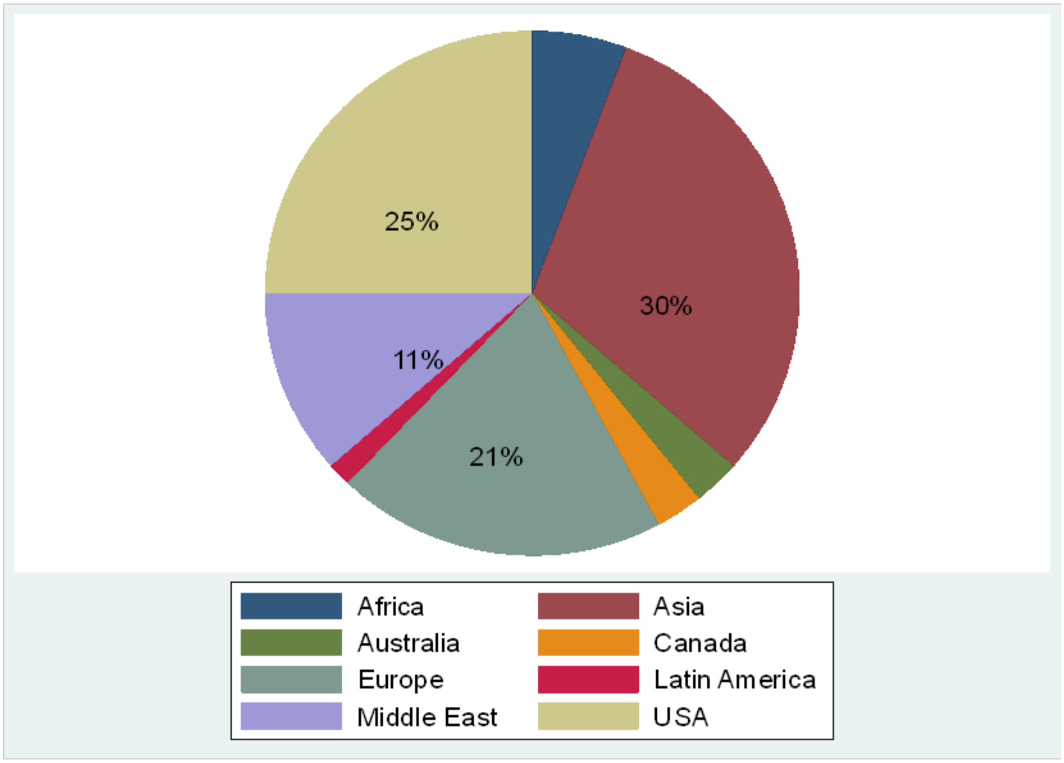

Figure 3: Healthcare logistics research development by geographic region

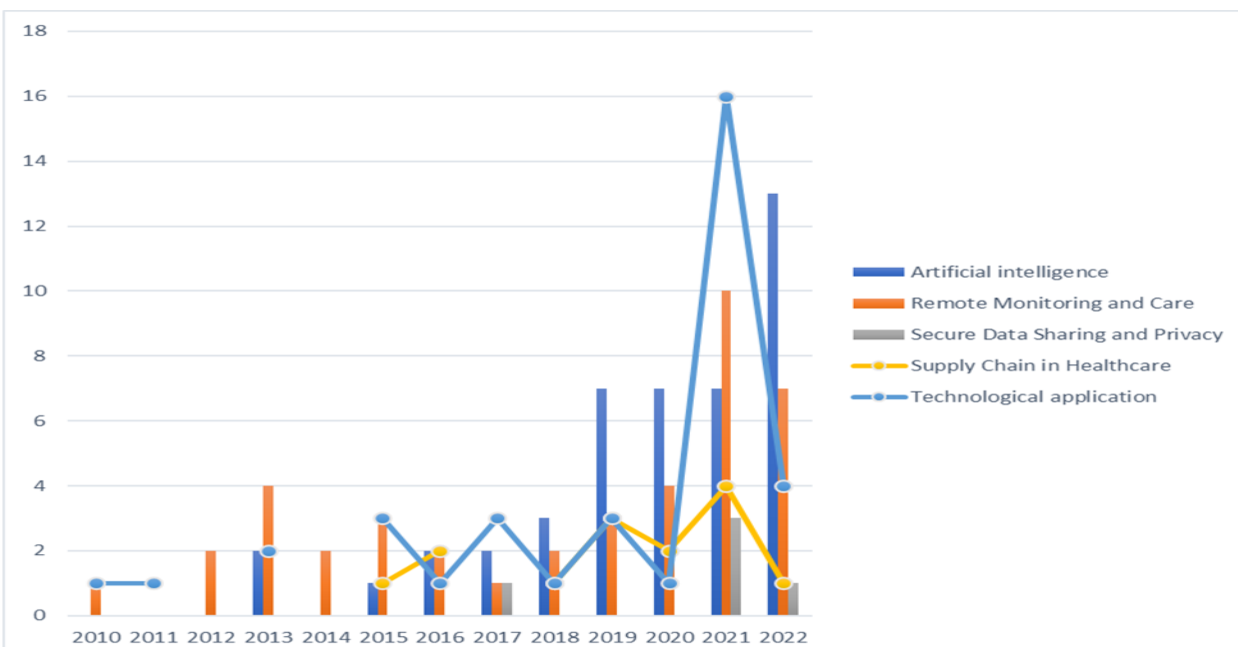

Figure 4: Trends in healthcare logistics research developments and technological applications

Supply Chain Management in Healthcare

The findings from this review revealed supply chain processes were strengthened through digital and automated tools like IoT-linked tracking sensors which improved transparency, shipment visibility, and inventory control through real-time monitoring of medical products(52-55). Evidences showed these tools reduced delays, tracking condition of medical products, and enhanced accountability across distribution pathways that upgraded patient care quality. Similarly, a study by Acevedo-Urquiaga et al. (2020) (52) addressed how IoT systems were used to monitor environmental conditions such as humidity and temperature in medication transport to prevent damage and wastage. Moreover, blockchain applications also emerged as a powerful mechanism for ensuring the authenticity of pharmaceutical products by creating tamper-proof digital ledgers and improved traceability and authenticity (56),(57) (58).The insights gained from these studies are valuable, particularly be emphasized in low-resource settings where vulnerabilities in the medicine supply chain are more common.

Technological Applications in Healthcare

Technological solutions such as electronic health records (EHR), telemedicine platforms, mobile health applications, and wearable sensors were widely recognized for improving healthcare workflow and logistics coordination(59-67). These, studies consistently showed that EHR integration reduced administrative delays, improved documentation accuracy, enhanced interdepartmental communication, and streamlined clinical logistics.

This review identified also the digital tools integration brings equity in healthcare access. For instance, telemedicine expanded service reach by enabling virtual and remote consultations so that reducing the need for physical facility visits(68). Moreover, mobile health applications assisted patients with self-monitoring, indirectly improving logistics efficiency by reducing unnecessary facility utilization and costs (69). The United States has emerged as the frontrunner in adopting digital logistics technologies, effectively becoming a reference point for how large-scale, tech-driven systems can be applicable across complex healthcare systems(59, 60, 65, 70, 71). Remarkably, the COVID-19 pandemic pushed this momentum and digital coordination tools shifted from being optional innovation to absolute necessities, supporting everything from remote patient care to the flow of critical supplies and the management of real-time data. This sudden reliance on technology not only reshaped logistical workflows but also set new expectations for how health systems must operate in a crisis, and beyond (72).

Artificial Intelligence (AI) in healthcare

AI applications emerged as one of the most transformative technological categories. AI-driven tools were used for predictive analytics for supply forecasting, risk identification in patient management, automated logistics scheduling and routing optimization for transport and deliveries(73, 74). Machine learning models enhanced the accuracy of supply-demand forecasting and reduced the risk of overstocking or shortages (49, 75-78). Ahn et al. (2021) demonstrated that predictive AI algorithms could independently analyze supply trends, helping facilities maintain optimal resource levels and reduce emergency procurement cycles (79)**.** Asia and the USA contributed the most AI-related publications, reflecting the growing global dependence on AI-supported logistics decision-making(48, 74, 79, 80).

Remote Monitoring and Care

This thematic analysis also revealed, remote patient monitoring systems and telehealth platforms are among healthcare optimization tools that have demonstrated their efficacy in enhancing patient outcomes, reducing hospital readmissions, and increasing access to care (40, 48, 60, 65, 67, 81-88). These systems are particularly beneficial for managing chronic conditions and post-operative care, where continuous monitoring is essential to safeguard patient’s life(48, 89). Patients can use wearable devices and remote monitoring systems to record vital signs and other health parameters with real -time data (90).Wearable devices and remote monitoring platforms enabled real-time data transmission, reducing hospital readmissions and improving clinical intervention timing. They also empowered patients and reduced healthcare facility burden by shifting some service components to outpatient or home-based models and becoming a viable solution for managing healthcare issues in both urban and rural settings, highlighting their potential adaptability(60, 91, 92).

Secure Data Sharing and Privacy

According to a study, data security and patient privacy were the main concerns in digital healthcare systems to fully exercise its potential benefits ((93). In line with this finding, the reviewed articles also emphasized that blockchain and advanced encryption techniques are essential for safeguarding patient information and maintaining data integrity, otherwise, security breach will happen(56, 88, 94). Importantly, blockchain provides a decentralized and tamper-proof ledger of transactions, which shields information from unauthorized access and supports the confidentiality of sensitive patient data throughout the supply chain (38, 56, 93, 94) and also complement by encryption to ensure confidentiality during data transmission across systems (38, 88). Middle Eastern countries reported increasing adoption of secure data technologies, influenced by region-specific data protection policies (38, 93). Table 2 summarizes the identified themes and their major healthcare applications.

Table 2: Summary of themes identified and their application in healthcare

Theme	Advancements	Authors
Supply Chain Management	Integration of IoT for real-time tracking of medical supplies and equipment IoT sensors for managing inventory levels and timely delivery Blockchain technology for an immutable ledger of transactions Ensuring the authenticity and integrity of pharmaceuticals - Application of blockchain for reliable records	(47, 119-127)
Technological Applications	Utilization of EHR systems for streamlined patient information management Mobile health applications for chronic condition tracking and lifestyle changes	(33, 35-37, 40, 50, 52-60, 63, 64, 71, 78, 83, 85, 113, 128-139) (140)
Artificial Intelligence (AI)	Application of AI for predictive analytics and decision support	(43-46, 67, 68, 71, 72, 75, 82, 111, 141-151)
Remote Monitoring and Care	Telemedicine for virtual consultations and access to remote areas and other technological platforms	(28, 29, 31, 32, 34, 61, 74, 76, 77, 79, 112, 114, 134, 152-179)
Secure Data Sharing	Secure sharing of patient data across departments and institutions	(31, 32, 85)

Discussion

The evidence gathered in this review demonstrates that institutional and infrastructural conditions within which the technologies are implemented can determine the effectiveness of technology-based logistics solutions. According to the reviewed studies, the value of these tools does not stem from being new or technical performance; rather, the way information moves through the system, how decisions are shaped, and how different actors coordinate logistical activities are more important. Among the tools examined, digital supply-chain platforms are consistently acknowledged for efficiency gains, largely because they enhance visibility across facilities and allow for quicker and informed decisions to emerging needs. Additionally, advanced tools like AI-based analytics and automation, showed promising move but tended to yield more uneven results as they require high technical capacity, organizational readiness, and operational stability for successful use. Similarly, secure data-sharing platforms helped to address concerns about traceability and verification, yet they also introduced new governance and interoperability challenges. Furthermore, remote monitoring technologies improved the reach of logistics functions beyond health facilities, though their effectiveness depended on reliable connections and user's readiness. The findings align with three complementary theoretical lenses that collectively explain technology adoption and logistics performance: SCOR Model that states technologies strengthened the Plan and Deliver components, improving forecasting and distribution; UTAUT where the included studies emphasized the enablers and barriers determining the adoption of these tools, and Information-Logistics Theory where the reviewed studies reveled the importance of information management for logistic efficiency.

The review also identified how the growing use of IoT and blockchain technologies optimized logistics practices within healthcare systems. The synthesized evidence yielded IoT devices, in particular, enable continuous visibility of both the location and the physical state of medical products as they move through the supply chain. This real-time information helps logistics teams respond more quickly to disruptions, maintain appropriate inventory levels, and avert stock shortages that can compromise patient care. Also, blockchain platforms complement these capabilities by providing secure, tamper-proof records of product movement which strengthens traceability and coordination across different stages of the supply chain(52-56). These technologies are more than innovations and they become the decision tools that keep modern health systems running, shaping everything from operational efficiency to real-time transparency and ensure clinical responsiveness across health systems.

Recent studies also evidenced blockchain technology complements this by providing a transparent and immutable ledger of transactions, guaranteeing the authenticity of products, and preventing tampering, thus maintaining the integrity of medical supplies and reducing the risk of wrong products entering the supply chain(95-97). In particular to blockchain application in healthcare, this review revealed two intertwined technological pathways, specifically, the use of blockchain to secure and verify supply chain transactions, and the deployment of IoT systems to provide continuous, real-time visibility over the flow of goods and information(95-97). It is revealed that the combination of these functions mitigates delays, reduce uncertainty, and strengthen the overall reliability of healthcare logistics that helps to overcome the increased pressure of rising healthcare costs and need for quality care services. Their combined influence reflects the broader technological landscape highlighted in this review and illustrating how digital infrastructures are actively reshaping supply chain strategies.

According to this finding the relevance of these tools in low-resource healthcare systems, where challenges such as poor documentation practices and limited traceability usually disrupt supply chain performance was the focus of many studies. In these settings, blockchain's auditability and IoT's tracking capabilities offer a practical means of closing long-standing information gaps. In line with these findings, Talpur et al. (2023) also pointed out that IoT and blockchain technologies could play an influential role in supply chain operations. Many researchers emphasized that, as global logistics systems become increasingly complex and interdependent, well-planned adoption of these tools is no longer optional. Instead, they are emerging as important enablers of long-term resilience, operational sustainability, and competitive strength across health-related and non-health–related supply chains alike(98).

While earlier reviews focused largely on traditional logistics management, such as facility-level material flow, procurement challenges, and waste management (19, 21, 26, 99), this review extend the field by illustrating how digital and automated technologies introduce fundamentally different capabilities in healthcare and clinical settings, beyond flow management. These include real-time sensing, predictive modeling, automated decision support, and secure data interchange, which were not adequately highlighted in earlier literature.

Additionally, the ethical issue related to digitalization and automation are the issues focused by this review as interoperability is one of the challenges that hinder the widespread adoption of technological innovations like EHR and telemedicine even though their improvements in healthcare logistics management is evident. This problem emerges from incompatible formats and standards used by different EHR systems which make it difficult to share patient information seamlessly among healthcare providers(100, 101) and it might lead to fragmented care and increased medical errors. Additionally, due to concerns about potential disruptions to their workflow and uncertainty about the benefits, healthcare providers acceptance is another critical barrier to technological integration(100, 102). Moreover a study emphasized regulatory compliance is also another potential barrier, as different regions have varying standards and regulations for health information technology utilization in patient care(103). The barriers highlighted in recent studies witnessed that technological innovation alone is insufficient to transform healthcare systems in any sustainable manner without corresponding investments in digital competency, organizational culture, and clear regulatory structures. Technologies introduced into environments that lack regulatory alignment or clear operational standards often lack implementation, regardless of their potential advantages(100, 103). Though this finding clearly showed that future research works focus on strategies that foster interoperability across platforms, strengthen user acceptance through meaningful engagement and training, and streamline regulatory processes to complement the developments in technology enabled logistics.

Furthermore, AI has emerged as one of the most influential tools shaping clinical practice through analytical tools capable of forecasting risks, guiding more precise interventions and personalized treatment plans(104-107). Evidence from diverse clinical settings illustrates that AI tools have identified malignancies that elude conventional interpretation; also, accurately signalled impending cardiac events in cardiology unit and they have detected early markers of acute kidney injury and sepsis(104-107). These evidences showed AI's ability to produce meaningful insights from complex data, its accuracy in synthesizing patient information for diagnostic support and its contribution to predict personalized care. A recent systematic review by Kitsios et al. (2023) supports this evidence, suggesting that AI will become integral components of routine decision-making and clinical workflows (108).

Despite the benefits, AI adoption is limited by concerns about algorithmic transparency, data quality, model generalizability, and ethical issues(108). The integration of AI into clinical practice needs well-structured planning to ensure that these systems are support clinicians rather than introduce complexity or work burden(105, 109). Therefore, the integration of these tools should focus not only their technical performance but also on how these tools align with

the established clinical routines, decision-making processes, and professional responsibilities. Hence, research must give greater attention to how AI models that are robust across varied datasets and resilient to the clinical variability will be applied in real-world settings. Such models should be capable of producing accurate, clinically interpretable forecasts across a complex medical data. At the same time, the growing reliance on AI raises ethical and legal questions(108). Issues surrounding the privacy, security, and permissible uses, require sustained investigation as AI systems become embedded in healthcare delivery(108). Future investigations should also identify the broader societal implications of its adoption and ensuring patient trust.
Remote monitoring technologies, such as telecardiology, have demonstrated efficacy in managing chronic conditions by enabling continuous health tracking and early intervention(110, 111). These systems allow for real-time transmission of vital signs and health data to healthcare providers, facilitating early management and timely adjustments to treatment plans, eventually improving patient outcomes and reducing healthcare costs(112). Additionally, remote monitoring technologies increase access to care, which is particularly beneficial in underserved areas and during public health emergencies or difficult-to-reach areas as well as in settings challenged by with human resource shortages (113-115). Despite the advantages there are also challenges that hinder widespread use of these technologies. Reviewed studies pinpointed that many health systems, particularly those in low-resource- settings struggle with unreliable power supply, poor internet access, and lack of technical skills to keep digital platforms functioning over time.

This review also identified, several studies frequently cited blockchain-based systems and modern encryption methods as promising approaches for future digitalization of healthcare system, because they create secure, traceable records(103, 116). Recent work by Nanou et al. (2023) and Naveed et al. (2023) reinforces this view, showing that distributed ledger designs and advanced cryptographic tools can strengthen security safeguards. At the same time, these authors also noted that implementing such technologies in low-resource environments introduces practical difficulties, including limited technical capacity and the need for substantial infrastructural support(103, 116), including computational requirements and regulatory compliance. It is proved that blockchain's decentralized and tamper-resistant structure offers a powerful safeguard against unauthorized alterations, preserving both the confidentiality and integrity of patient records(117) through encryption that transforms sensitive health information into encoded forms that can be accessed only by individuals with the proper authorization, and defence against data breaches(118).

Despite these advantages, the adoption of such technologies into resource-constrained settings remains challenging due to high computational demands, limited digital infrastructure, and lack of regulatory frameworks(103).

Accordingly, future research should focus on cost-effectiveness of these tools, context-appropriate encryption models, and simplified compliance frameworks that will be essential for data security, and safeguarding privacy across diverse healthcare ecosystems.

Due to socioeconomic and regulatory factors adopting healthcare logistics technologies vary across regions (119). For instance, the success of remote monitoring technologies in the USA(70, 71, 120, 121) may offer lessons how infrastructure development influence other regions looking to implement similar solutions and why low-income countries are lagging behind from automating their healthcare. A study by Phee, JS. et al. (2012) identified automation and robotics in healthcare is challenged by design complexity and lack of adequate expertise (44), implying the importance of knowledge and skill transitions with the technology. Rghioui A. et al. (2021) studied the use of RFID technology for disease prediction and emphasized its characteristics as low-cost (122); representing adaptable technologies to low-resource settings.

Rupa Ch et al. (2022) studied the practical application and feasibility of blockchain for deployment in low-resource settings and suggested simplifying the user interface and interaction design to make it more user-friendly and accessible for individuals with limited technical expertise(123) and Tiye K. and Gudeta T. (2018) studied challenges in LMIS(logistics management information system) on data quality and system performance and recommended Electronic LMIS (e-LMIS) to streamline data management processes, enhance accuracy and overall logistics management information system performance in public health facilities(124). These adaptations demonstrate that technological logistics solutions can be feasible even in constrained environments when local needs and capacities are core. These adaptations demonstrate that technological logistics solutions can be feasible even in constrained environments when local needs and capacities are considered.

Benefits
The integration of these technologies in healthcare logistics has been shown to improve efficiency, reduce costs, and enhance patient care(47-51).

Challenges
Despite the benefits there are several challenges identified by the reviewed articles. These include the high cost of implementing advanced technologies, the need for training and support for healthcare staff, and concerns about data privacy and security(125-

127). Additionally, integrating new technologies into existing logistics systems can be complex and time-consuming, particularly for the clinicians(128).

Conclusion

In summary, the results of this review revealed that digital supply chain systems enhanced performance of healthcare systems, with advanced technologies and artificial intelligence solutions offering targeted benefits in settings with adequate infrastructure. Also, the role of secure data-sharing was significant in establishing trust across supply chain networks, while remote monitoring systems recognized to link facility-based care to community-level care.

The review further highlighted the importance of maintaining a balanced view that acknowledges both the transformative potential of these tools and the practical barriers that must be addressed for effective implementation, rather than only promoting the advantages.

Moreover, prioritizing efforts in system compatibility, policy development, personnel training, and infrastructure enhancement is fundamental to scaling these technological solutions. Subsequent investigations should prioritize practical deployment challenges, and generate evidence regarding long-term viability and healthcare system effects.

Limitations

This review could stem from publication bias usually studies yielding positive results are more inclined to be published. Additionally, the extent of the literature search might have overlooked certain relevant studies, particularly those available in languages other than English. Owing to the vast area of the healthcare logistics domain, the review could not comprehensively cover all aspects of the field. Its primary objective is to deliberate on the recent advancements in technology-enabled logistics and tools in the healthcare industry while furnishing pertinent research.

Abbreviations

ALSI- Abstract Lacks Sufficient Information
ISF- Irrelevant Study Focus
LRD-Lack of Relevant Data
FTNA-Full Text Not Available
LR-Language Restrictions

Declaration

We declare that we shall not submit the paper for publication in any other Journal till journal editors make the decision

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Data availability

The corresponding author has found the data reported in this manuscript and will be available upon reasonable request.

Authors' contributions

Mulu Negawo: Conception, Methodological Design, acquisition of data, analysis, and interpretation of data, drafting the article, and final approval of the version to be submitted

Yadeta Dessie: approved methodological design, revised the article critically, gave scholarly input and final approval of the version to be submitted
Girma Geberesenbet: acquisition of data, approved methodological design, revised the article critically, gave scholarly input and final approval of the version to be submitted

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The authors have no competing interest to declare

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