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Changes in resilience models in the healthcare supply chain

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Abstract: The events of the last five years have had a huge effect on the healthcare supply chain. The system has encountered challenges such as the COVID-19 pandemic and political conflicts. At the same time, sustainability pressures are increasing. These disruptive incidents have revealed weaknesses in the supply chain and lack of resilience. As a result, changes in resilience models have begun to be planned and implemented. The article looks at the main changes in resilience models, emphasizing new models, measures, and attitudes to ensure healthcare logistic. Factors such as risk forecasting, diversification of supply sources, the impact of digitalization, timely inventory management, and strengthening cooperation with suppliers are analyzed. Models that are oriented toward greater flexibility and systemic resilience assessment in general are also discussed. Based on the literature review, it can be concluded that the development of dynamic, predictive, and technology-based robustness models can minimize the harm caused by supply chain disruptions and ensure the stability of the healthcare system. The results of the review indicated that the newest direction for models is the flow of smart technologies. This is expensive, but digitalization can ensure a robust supply chain in the healthcare sector.

1 Introduction

The pandemic has shown that the healthcare supply chain is extremely sensitive and vulnerable. Ongoing political conflicts and the growing importance of sustainability have prompted both scientists and practitioners to look for new ways to ensure the resilience of the system. The OECD report (2025) notes that the dependence on smaller supply sources is increasing. As a result, the vulnerability of the supply chain is growing. The healthcare sector needs to be resilient to unpredictable disruptions, as the services it provides are directly related to saving lives and safeguarding health. Supply chains are complex, interconnected, and limited, which has led to a major shift in how we think about resilience. New models that are more adaptable, more accurate in their predictions, and more technologically innovative need to be planned and developed.

For a long time, logistic models were based on the just-in-time principle, with centralized suppliers and minimal stocks. However, over time, these methods proved to be outdated and unable to protect against sudden disruptions. During COVID-19 in particular, there was a shortage of equipment and medicines, and supply processes were delayed. As a result, it became clear that traditional supply models are more suitable for responding after an event has occurred. Flexible and proactive supply chain resilience models need to be developed to prevent unpredictable events. It should be noted that the development of resilience strategies is integral to effective risk management in the supply chain. In view of this, it is clear that resilience should become a priority for the management of organizations. According to the latest provisions of the World Economic Forum (2025), it is necessary to strengthen not only the operations of the chain, but also to increase the resilience of the employees themselves.

It should be noted that resilience is now understood not only as the capacity to recover from disruptions, but as the ability of the entire system to predict, adapt, and maintain its effectiveness even when circumstances change.

This article aims to look at changes in vulnerability models for the healthcare supply chain. It also assesses the reasons for these changes and analyzes current solutions and challenges faced in this sector. Furthermore, it also looks at how these trends can help make the system more robust and sustainable. Based on a review of the scientific literature, it is discusses trends in vulnerability models in the healthcare sector. The relevance of the analysis is determined by the need to develop more efficient, sustainable, and resilient supply chains that would ensure the stability of the healthcare system and its ability to respond to emerging critical situations.

The following tasks were outlined to achieve the purpose of the study:

O1.: to conduct a comprehensive analysis of the literature;

O2.: to provide detailed changes in resilience models and their impact on supply chain operations.

Statistical methods were used to analyze the data and draw conclusions. Tables and diagrams detail the results, with the methodology of the literature analysis presented in the chart.

The article consists of the following parts: introduction, literature review, research methodology, presentation of results, and discussion. The introduction briefly summarizes the relevance of the problem. It explains the reasons for the vulnerability of the healthcare supply chain and what is needed to make the system resilient and ensure service delivery. The literature review section presents basic definitions, research made by other scientists, and their results. The methodology part details the steps and actions taken to perform the literature review. The results obtained from the analysis are presented in the following section. The results are described and illustrated graphically. The discussion section summarizes the results, the findings of other researchers' analyses, and outlines directions for future research.

2 Literature review

This subsection provides definitions of key terms that are important and used throughout this article.

Supply chain – a network of interrelated organizations and service providers that work together to ensure the quality of products or services and protect information, equipment and facilities at every stage of the supply chain [1]. This is a huge flow of information, finances, and management.

Healthcare supply chain - is a flow of management stakeholders, manufacturers, distributors, hospitals, pharmacies, insurance providers, and, of course, patients and the flow of all resources from the manufacturer to the patient [2]. The healthcare supply chain consists of the supply of medicines, medical equipment, various devices, and other essential resources. The healthcare supply chain is particularly vulnerable to disruptions, as the health of the entire population, and often people's lives, depend on its proper functioning. In the last few years, the supply chain has been affected by factors such as the pandemic, political conflicts, climate change challenges, and cyber security. These major events have highlighted the weak parts of the supply chain. This has led to improvements in existing models and the search for new models to make the supply chain more resilient.

Supply chain resilience - this is the ability of the supply chain to adapt to unexpected disruptions, prevent the spread of disruptions by maintaining control over structures and functions, and recover, ensuring the continuity of the supply chain [3]. Resilience is a property that is necessary for both organizations and processes.

Businesses only recognized the importance of resilience around 2000, when tragic events shocked the world. Fuel protests in Europe and a terrorist attack in the USA 2001 [1]. These events prompted concern to find new ways to prevent such disasters in the future. Resilience is the fundamental ability of a supply chain to cope with and adapt to unanticipated disruptions as they occur [2]. However, it can have more meanings depending on the perspective [3]. Since the start of the pandemic, this capability has become a priority for many organizations [4-6].

Several common concepts of supply chain resilience can be found in the scientific literature it is show in Figure 1.

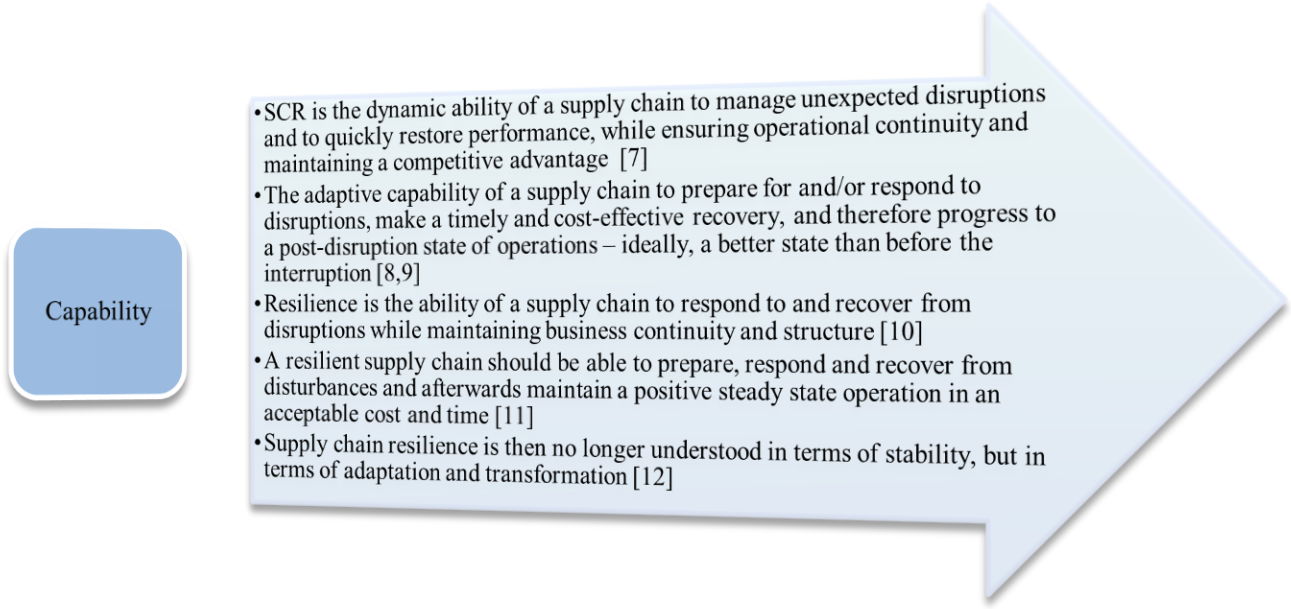

Figure 1 Definitions of supply chain resilience [7-12]

To summarise the Figure 1, supply chain resilience is a capability. Most authors also agree that the ability of the supply chain to withstand unforeseen events and to return to its original state are the most critical resilience factors.

Supply chains in the healthcare sector are different because the focus is on saving lives rather than generating income. In this way, the health system supply chain is unusual [13]. In the supply chain, healthcare providers (clinics, hospitals, private/public) are the organizations that work with patients and create demand throughout the healthcare supply chain [14]. They differ from typical supply chains in terms of high-value products and high complexity and unpredictable provision. There are shown the supply chain resilience models analyzed by the authors in the Figure 2.

Figure 2 The most common supply chain resilience models

Several insights can be made when evaluating the Figure 2. There are many models of resilience in the entire health system - diagnostic questions are analysed, the resilience of health system workers is extensively explored, especially during the Covid period. There is not much research that examines supply chain resilience patterns across the entire healthcare system. We can see that in previous years models are analyzed which explore the factors of cooperation, organizational cultural influence. In recent years, we can see a trend towards the increasing use of models based on smart technologies. They are fast, reliable, able to process huge amounts of information [15]. Artificial intelligence-driven techniques, such as forecasting systems and identification of supplier-buyer relationships, can be valuable in increasing supply chain visibility [16]. Supply chain visibility can be provided as an integrated application solution.

According to Pournader (2020), health system supply chains in particular should adopt a multi-level approach to addressing resilience management. This approach includes the management between the individual, the organization, and all stakeholders and their combined impact on supply chain resilience [17]. However, models are affected by many drivers.

2.1 Determinants of changes in patterns

Both societal and global political developments have created the conditions for the health system to change and adapt. A healthcare system that wants to ensure proper functioning must take group measures. Resilience solutions must integrate technology, collaboration, and system visibility [18]. It should be noted that research is increasingly recognizing the usefulness of innovative technologies in increasing the resilience of the supply chain and improving its visibility. However, there are still not enough analyses to confirm this [19]. Based on scientific literature, below are several factors that are significant for the creation of new supply chain resilience models.

Supply chain risk management

In addition, supply chain resilience is closely related to supply chain risk management. After all, the most important goal of risk management is to protect the supply chain from unwanted events [6]. According to Majumdar (2021), organizations that want to create a resilient supply chain should prioritize risk mitigation strategies, and based on the results, adopt a set of strategies [20]. Choosing the right strategies can make sure the chain keeps running smoothly.

Innovative technologies

Another significant reason is technological changes. According to Arji (2023), artificial intelligence, blockchain, big data analytics, and modelling are the most important technologies used in healthcare supply chain management [18]. In the literature, digital technologies are considered essential resources for supply chains to stay up and running. Using these technologies makes supply chains more resilient, agile, and visible [19]. Digitalization is considered an important element in a huge variety of logistics elements.

Global disruptions

The COVID-19 pandemic is also a significant factor that has created a need to improve existing resilience systems. Indeed, the disruptions caused by the pandemic have highlighted serious weaknesses in the health system. During the pandemic, it was difficult to ensure the delivery of health services. This has led to an increased need to strengthen the resilience of the whole health care system [20,21].

Sustainability factor

Sustainability and resilience. The growing importance of sustainability highlights that harmonizing environmental and governance aspects positively impacts supply chain efficiency [20]. Based on the latest academic insights, sustainability is currently one of the most crucial aspects of healthcare systems and one of the most pursued practices [21]. The healthcare sector comprises a significant part of the economies of both the world and every country. Therefore, it must follow sustainability trends [22].

Legal provisions

In addition, changes in political decisions and regulatory frameworks must be mentioned. Based on the World Health Organization's position, countries are increasingly required to ensure the preparedness, resilience, and sustainability of their supply chains [23]. Mandal (2023) published a study in 2017 that was the first to mention indicators for measuring resilience in the healthcare industry.

2.2 Overview of current models of resilience

The issue of supply chain resilience has been under discussion for some time. Some countries have tried to develop possible resilience models. In this paragraph, it will be discussed how they have fared and succeeded.

Figure 3 shows the most prominent trends in resilient models.

Based on a review of the literature and the work of other authors, resilience models can be divided into the following groups:

- Technological;
- Organizational;
- Sustainability;
- Human flows.

Technological models are the fastest growing area, but their implementation requires the largest investments and poses new risks. Organizational models are more dependent on the quality of cooperation, but can be implemented more quickly and cheaply. Sustainability models provide a long-term competitive advantage but may conflict with short-term economic goals. Human resource resilience is a key element in ensuring that technologies and processes are effectively adapted in crises. Future research should combine all four categories to achieve systemic resilience in the healthcare delivery chain.

Trends of resilience models:

• Developing the use of innovative technologies: digital technologies such as artificial intelligence and big data mining have been introduced in many countries around the world. Due to innovation, organizations have been able to quickly optimize stock management and forecast demand.

• Blockchain technology: blockchain technology is being widely deployed to ensure supply chain transparency and security.

• Supplier diversification: one of the tools to reduce supply chain risks. It is the possibility of having all suppliers in one place, as well as having several suppliers for the same product. This ensures that the supply chain can respond quickly if any source of supply becomes inoperative.

• Integrating multiple systems: integrating the health system supply chain and crisis management in general into one single system. This creates a common strategy to ensure supply, storage of products, and response to a crisis incident.

Figure 3 Trends of resilience models

2.3 Challenges of new models implementation

So, the studies show how important it is to use smart technology and develop new models to keep supply chains working smoothly. But there are some challenges to implementing this.

First of all, it should be noted that research on barriers to technology implementation is limited. The studies that have been conducted are fragmented. However, one of the key problems identified is miscommunication between managers and implementers. Other barriers include inter-organizational, social, and environmental issues [24].

Furthermore, scientists no longer doubt the importance of digital technologies in ensuring the resilience of organizations. However, at the same time, new technologies increase cyber security risks for organizations implementing this process [25]. The risk of data leaks and cyber attacks is growing.

In addition, every organization faces significant organizational challenges when introducing improvements. Due to changes in the organizational and hierarchical structures, collaboration between departments is becoming complicated. This hinders the dissemination and implementation of new technological solutions [26]. It has also been found that a lack of understanding among senior staff and management poses major challenges to the adoption of innovations [27]. It should be emphasized that the success of any technically innovative solution depends on the competence and skills of qualified professionals. However, considering that the healthcare sector is not attractive to these professionals, organizations may face challenges related to the lack of technical competence [28]. Therefore, it is the healthcare sector that must make efforts to ensure that the necessary functions are performed by competent personnel.

Also, successful technological growth needs enough management of financial resources [29]. In order for new systems to function effectively and remain competitive, they need to be maintained and continuously improved. This requires ongoing financial resources [30].

3 Methodology

This review aimed to analyze which supply chain resilience models are applied in the healthcare system and how they have changed. To this end, a literature review was conducted to identify trends in the relevance of the topic, changes in models, and their causes. Future research directions were also determined.

Criteria for inclusion of literature sources:

- Scientific articles in peer-reviewed journals;
- Publications from 2014 to 2024;
- Articles in English;
- Research investigating models of resilience in healthcare supply chains.

Criteria for exclusion of literature sources:

- Articles in non-peer-reviewed journals;
- Research papers not related to supply chains in the healthcare sector.

The search for publications was conducted in the following databases: Scopus, Web of Science, PubMed.
The following code phrases were used for the search: “healthcare supply chain“ AND “resilience models“.

In addition, a time filter (articles published between 2014 and 2024) and a language filter (only articles in English) were used to select the articles. When processing the list of articles, the data was transferred to Excel. The publication selection procedure is illustrated in the Figure 4 below.

After selecting the appropriate articles, a further selection was made based on the keyword "resilience models." This was done with the aim of identifying traditional and new resilience models and assessing their suitability for the healthcare system in emergency situations. The application of models is analyzed and conclusions are drawn from selected publications.

When evaluating the results, we would like to draw attention to the year 2020. Scientists regard 2020 as the turning point when the topic of resilience became particularly relevant.

Figure 4 Publication selection process

4 Results and discussion

A review of the literature uncovered a few trends in models of resilience in healthcare supply chains. First, models have become systemic, involving both technological and organizational decisions. Second, resilience is equated with the ability to predict and adapt, rather than just react after an event. There is also a clear role for technology in creating a smooth supply chain. Furthermore, a method of supplier diversification has been discovered that reduces territorial dependence. In addition, the importance of collaboration should be highlighted. All this shows that achieving resilience is becoming a strategic priority for organizations.

Table 1 below shows the number of publications found in databases during the period under review.

Table 1 Number of articles by topic

Year	Databases		
	Web of Science	Scopus	PubMed
2014	0	0	0
2015	0	0	0
2016	0	0	0
2017	1	1	0
2018	1	0	0
2019	2	2	1
2020	4	4	4
2021	13	5	4
2022	14	8	7
2023	15	15	6
2024	15	31	7
Total:	**65**	**66**	**29**

The results of Table 1 reveal that the top of the issue's relevance will be in 2022-2023. This is the period following the COVID-19 pandemic and the start of military conflicts. These data confirm the results of studies carried out by other researchers. Considering the number of publications in the relevant years, it is worth taking data from 2020 onwards for future research.

Further analysis of the literature resulted in a counted number of articles that examined health system resilience models during the period in a review. The results are presented in Figure 5.

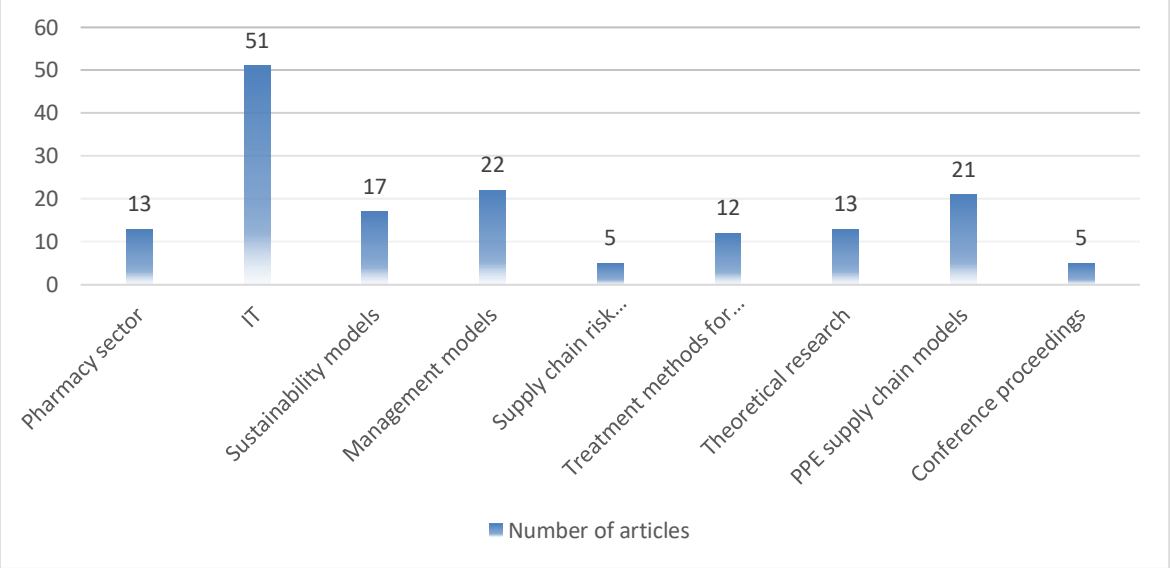

Figure 5 Number of publications of resilience models

The study's results indicate that digitalization, collaboration, and sustainability are the most crucial factors in ensuring supply chain resilience. The findings of the analysis confirm the results of other researchers that organisations are increasingly implementing digital technologies and seeking sustainability.

The data analysis aimed not only to clarify the context in which the models are applied, but also how the scientific community's interest in this issue has changed. Figure 6 shows how researchers' attention to the vulnerability of the healthcare supply chain has changed over time.

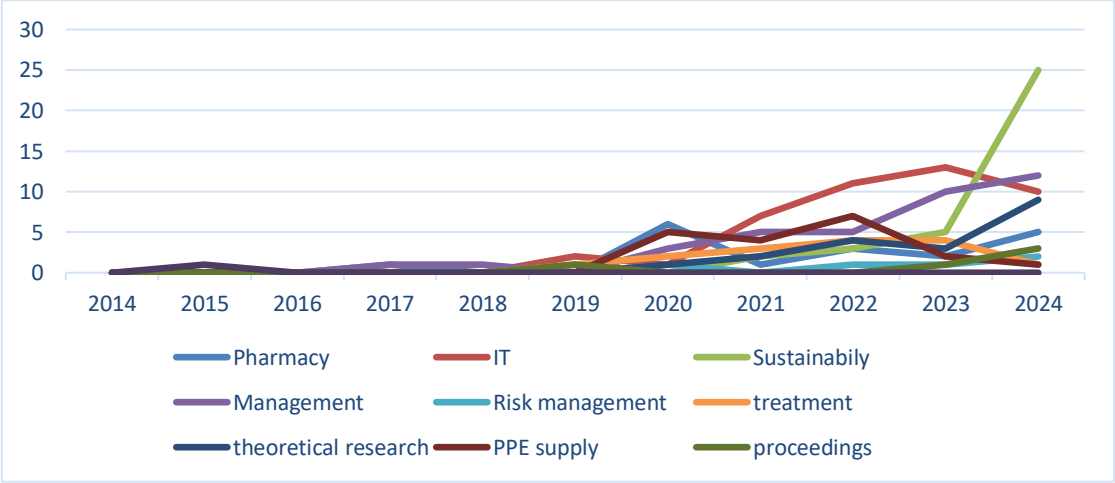

Figure 6 Trends in interest in the resilience of the healthcare supply chain

Figure 6 shows that the relevance of the topic is increasing towards 2019. The importance of IT and digitalization is already becoming significant. The peak for most of the models studied can be considered to be 2022-2023. The relevance of IT and supply chain management models is growing particularly rapidly. It is likely that digitalization will accelerate and the need for sustainability will increase in the future.

Changes in supply chain resilience patterns in the healthcare sector have a major impact.

The analysis indicates that the development of new preparedness strategies requires a new understanding and management of risks in the healthcare supply chain. In order to increase understanding, it is necessary to invest in the human flows. Employees must not only be resilient, but also have the necessary skills.

• The use of digital technologies enables organizations to detect disorders early, evaluate situations flexibly, and make timely decisions. Artificial intelligence devices are equipped to continuously monitor the operating environment and identify disruptions. Technology enables systems to be faster, with the ability to handle large amount of data, so that all processes are faster. This increases the efficiency of health system operations. Integrating social factors into supply chain resilience strategies is a way to lower the risks to the whole system.

• Intersectoral collaboration. Agility in partnerships reduces risks associated with dependence on suppliers and circumstances. Integrating social factors into supply chain resilience strategies is a way to lower the risks to the whole system.

• The role of sustainability is crucial. Sustainable factors are among the most significant risk management factors. Integrating social factors into supply chain resilience strategies is a way to lower the risks to the whole system.

• Financial costs. According to the World Health Organization, not all healthcare systems have the same financial capacity to keep up with technological innovations [31]. Countries should look into strategic investments to build new and promising ways to be more resilient.

In general, the impact of changes in models in healthcare involves both processes and deliverables, the advantages offered by the new models contribute to a more flexible, responsive, and socially responsible healthcare system supply chain. All of this is crucial when it comes to preparing for future crises. The new strategies have clear benefits in terms of enhancing the delivery of healthcare services and increasing the resilience of the whole system. However, the challenges of developing and implementing models highlight the complexity of transitioning to new strategies.

Recent studies examine the potential of artificial intelligence and blockchain technologies in ensuring the resilience of healthcare systems. However, the business community is calling for a return to a focus on people—developing their competencies, skills, and, of course, resilience. And ultimately, we see that we cannot rely only on technology, just as we cannot depend entirely on people. To achieve optimal results, a symbiosis between people and technology is essential.

5 Conclusions

In summarizing, it can be seen that resilience strategies in the healthcare supply chain are strongly dependent on the uncertain global situation. In the future, resilience models should be driven by technological innovations, new methods of collaboration, and sustainability requirements. The modern supply chain must be not only robust, but also agile, sustainable, and socially responsible. Scientists, politicians, and practitioners must cooperate to create resilient supply chains. Today's supply networks are oriented toward smart systems and process automatization. There is a tendency to have more than one supplier and to ensure the sustainability of operations.

Today's supply networks are oriented toward smart systems and process automatization. There is a tendency to have more than one supplier and to ensure the sustainability of operations. The development and implementation of new resilience models unequivocally require significant financial investment and strong political decisions.

Based on the results of the review, there are some recommendations for politicians, leaders, and academics:

• Create and incorporate safety systems to minimize cyber risks and protect data.

• Encourage multisectoral cooperation to provide all organizations with sufficient financial resources.

• Focus not only on technological aspects, but also on human resources to build organizational resilience.

This analysis presents not only the resilience models that are currently in place or being developed in the healthcare supply chain. It also analyzes changes in these models and their causes. In addition, the models are briefly described and their differences are highlighted.

References

[1] ISLAM, M.D.: A survey on the use of blockchains to achieve supply chain security, *Information Systems*, Vol. 117, pp. 1-17, 2023. https://doi.org/10.1016/j.is.2023.102232

[2] FIORE, M., CAPODICI, A., RUCCI, P., BIANCONI, A., LONGO, G., RICCI, M., SANMARCHI, F., GOLINELLI, D.: Blockchain for the Healthcare Supply Chain: A Systematic Literature Review, *Applied Sciences*, Vol. 13, No. 2, 686, pp. 1-14, 2023. https://doi.org/10.3390/app13020686

[3] DUBEY, R., BRYDE, D.J., DWIVEDI, Y.K., GRAHAM, G., FOROPON, C., PAPADOPOULOS, T.: Dynamic digital capabilities and supply chain resilience: The role of government effectiveness, *International Journal of Production Economics*, Vol. 258, pp. 1-16, 2023. https://doi.org/10.1016/j.ijpe.2023.108790

[4] FAGGIONI, F., ROSSI, M.V., SESTINO, A.: Conceptualizing supply chain resilience in exogenous crisis times: toward a holistic definition, *Journal of the Knowledge Economy*, Vol. 15, pp. 17308-17332, 2024. https://doi.org/10.1007/s13132-024-01816-0

[5] TUKAMUHABWA, B.R., STEVENSON, M., BUSBY, J., ZORZINI, M.: Supply chain resilience: definition, review and theoretical foundations for further study, *International Journal of Production Research*, Vol. 53, pp. 5592-5623, 2015. https://doi.org/10.1080/00207543.2015.1037934

[6] CERABONA, T., BENABEN, F., MONTREUIL, B., LAURAS, M., FAUGERE, L., CAMPOS, M.R., JEANY, J.: The physics of decision approach: a physics-based vision to manage supply chain resilience, *International Journal of Production Research*, Vol. 62, pp. 1783-1802, 2023. https://doi.org/10.1080/00207543.2023.2201637

[7] CASTILLO, C.: Is there a theory of supply chain resilience? A bibliometric analysis of the literature, *International Journal of Operations & Production Management*, Vol. 43, No. 1, pp. 22-47, 2023.

https://doi.org/10.1108/IJOPM-02-2022-0136
[8] RIBEIRO, J.P., POVOA, A.B.: Supply Chain Resilience: Definitions and quantitative modelling approaches – A literature review, *Computers & Industrial Engineering*, Vol. 115, pp. 109-122, 2018. https://doi.org/10.1016/j.cie.2017.11.006
[9] WIELAND, A., DURACH, C.F.: Two perspectives on supply chain resilience, *Journal of Business Logistics*, Vol. 42, pp. 315-322, 2021. https://doi.org/10.1111/jbl.12271
[10] PEREIRA, C.R., CHRISTOPHER, M., LAGO DA SILVA, A.: Achieving supply chain resilience: the role of procurement, *Supply Chain Management*, Vol. 19, No. 5-6, pp. 626-642, 2014. https://doi.org/10.1108/SCM-09-2013-0346
[11] VANANY, I., ALI, M.H., TAN, K.H., KUMAR, A., SISWANTO, N.: A Supply Chain Resilience Capability Framework and Process for Mitigating the COVID-19 Pandemic Disruption, *IEEE Transactions on Engineering Management*, Vol. 71, pp. 10358-10372, 2024. https://doi.org/10.1109/TEM.2021.3116068
[12] NEGRI, M., CAGNO, E., COLICCHIA, C., SARKIS, J.: Integrating sustainability and resilience in the supply chain: A systematic literature review and a research agenda, *Business Strategy and the Environment*, Vol. 30, No. 7, pp. 2858-2886, 2021. https://doi.org/10.1002/BSE.2776
[13] ALTAY, N., PAL, R.: Coping in supply chains: a conceptual framework for disruption management, *International Journal of Logistics Management*, Vol. 34, No. 2, pp. 261-279, 2023. https://doi.org/10.1108/IJLM-05-2021-0305
[14] RAJ, A., MUKHERJEE, A.A., DE SOUSA JABBOUR, A.B.L., SRIVASTAVA, S.K.: Supply chain management during and post-COVID-19 pandemic: Mitigation strategies and practical lessons learned, *Journal of Business Research*, Vol. 142, pp. 1125-1139, 2022. https://doi.org/10.1016/J.JBUSRES.2022.01.037
[15] YUAN, Y., LI, W.: The effects of supply chain risk information processing capability and supply chain finance on supply chain resilience: a moderated and mediated model, *Journal of Enterprise Information Management*, Vol. 35, No. 6, pp. 1592-1612, 2022. https://doi.org/10.1108/JEIM-09-2021-0383
[16] PHARES, J., DOBRZYKOWSKI, D.D., PROHOFSKY, J.: How policy is shaping the macro healthcare delivery supply chain: The emergence of a new tier of retail medical clinics, *Business Horizons*, Vol. 64, No. 3, pp. 333-345, 2021. https://doi.org/10.1016/J.BUSHOR.2021.02.040
[17] SENNA, P., REIS, A., SANTOS, I.L., DIAS, A.C., COELHO, O.: A systematic literature review on supply chain risk management: is healthcare management a forsaken research field?, *Benchmarking: An International Journal*, Vol. 28, No. 3, pp. 926-956, 2021. https://doi.org/10.1108/BIJ-05-2020-0266
[18] SPIESKE, A., BIRKEL, H.: Improving supply chain resilience through industry 4.0: A systematic literature review under the impressions of the COVID-19 pandemic, *Computers & Industrial Engineering*, Vol. 158, pp. 1-22, 2021. https://doi.org/10.1016/J.CIE.2021.107452
[19] KOSASIH, E.E., MARGAROLI, F., GELLI, S., AZIZ, A., WILDGOOSE, N., BRINTRUP, A.: Towards knowledge graph reasoning for supply chain risk management using graph neural networks, *International Journal of Production Research*, Vol. 62, No. 15, pp. 5596-5612, 2024. https://doi.org/10.1080/00207543.2022.2100841
[20] POURNADER, M., KACH, A., TALLURI, S.: A Review of the Existing and Emerging Topics in the Supply Chain Risk Management Literature, *Decision Sciences*, Vol. 51, No. 4, pp. 867-919, 2020. https://doi.org/10.1111/DECI.12470
[21] PIFFARI, C., LAGORIO, A., PINTO, R.: Challenges in Healthcare Supply Chain Resilience Management: A Conceptual Framework, *IFAC-PapersOnLine*, Vol. 58, No. 19, pp. 1126-1131, 2024. https://doi.org/10.1016/J.IFACOL.2024.09.116
[22] TIWARI, M., BRYDE, D.J., STAYROPOLOU, F., DUBEY, R., KUMARI, S., FOROPON, C.: Modelling supply chain Visibility, digital Technologies, environmental dynamism and healthcare supply chain Resilience: An organisation information processing theory perspective, *Transportation Research Part E: Logistics and Transportation Review*, Vol. 188, pp. 1-21, 2024. https://doi.org/10.1016/J.TRE.2024.103613
[23] MAJUMDAR, A., SINHA, S.K., Govindan, K.: Prioritising risk mitigation strategies for environmentally sustainable clothing supply chains: Insights from selected organisational theories, *Sustainable Production and Consumption*, Vol. 28, pp. 543-555, 2021. https://doi.org/10.1016/J.SPC.2021.06.021
[24] ARJI, G., AHMADI, H., AVAZPOOR, P., Hemmat, M.: Identifying resilience strategies for disruption management in the healthcare supply chain during COVID-19 by digital innovations: A systematic literature review, *Informatics in Medicine Unlocked*, Vol. 38, pp. 1-15, 2023. https://doi.org/10.1016/J.IMU.2023.101199
[25] ALVARENGA, M.Z., DE OLIVEIRA, M.P.V., DE OLIVEIRA, T.A.G.F.: The impact of using digital technologies on supply chain resilience and robustness: the role of memory under the covid-19 outbreak, *Supply Chain Management*, Vol. 28, No. 5, pp. 825-842, 2023. https://doi.org/10.1108/SCM-06-2022-0217
[26] DA ROSA, V.M., SAURIN, T.A., TORTORELLA, G.L., FOGLIATTO, F.S., TONETTO, L.M., SAMSON, D.: Digital technologies: An exploratory study of their role in the resilience of healthcare services, *Applied ergonomics,* Vol. 97, pp. 1-13, 2021. https://doi.org/10.1016/j.apergo.2021.103517

[27] CHEN, X., HE, C., CHEN, Y., XIE, Z.: Internet of Things (IoT)—blockchain-enabled pharmaceutical supply chain resilience in the post-pandemic era, *Frontiers of Engineering Management*, Vol. 10, No. 1, pp. 82-95, 2023. https://doi.org/10.1007/s42524-022-0233-1

[28] AGBAKWURU, V., ONYENAHAZI, O.B., ANTWI, B.O., OYEWALE, K.: The Impact of Environmental, Social, and Governance (ESG) Reporting on Corporate Financial Performance, *International Journal of Research Publication and Reviews*, Vol. 5, No. 9, pp. 3629-3644, 2024. https://doi.org/10.55248/gengpi.5.0924.2710

[29] KAOKPHANVANICH, C., RATTANAWONG, W., VONGMANEE, V.: A New Model for a Sustainable Healthcare Supply Chain Prioritizes Patient Safety: Using the Fuzzy Delphi Method to Identify Healthcare Workers' Perspectives, *Sustainability*, Vol. 15, No. 9, 7123, pp. 1-23, 2023. https://doi.org/10.3390/SU15097123

[30] SEPETIS, A., RIZOS, F., PIERRAKOS, G., KARANIKAS, H., SCHALLMO, D.: A Sustainable Model for Healthcare Systems: The Innovative Approach of ESG and Digital Transformation, *Healthcare 2024*, Vol. 12, No. 2, 156, pp. 1-18, 2024. https://doi.org/10.3390/HEALTHCARE12020156

[31] WORLD HEALTH ORGANISATION: *Framework for strengthening health emergency preparedness in cities and urban settings*, World Health Organization, 2021.

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