

Assembling the avengers! Trends and knowledge themes in 100 most-cited publications on the blood supply chain: a bibliometric analysis

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Abstract

Purpose – This paper assembles the 100 most-cited journal articles and reviews on the blood supply chain to analyze the research trends and knowledge themes.

Design/methodology/approach – The study conducted a bibliometric analysis of the 100 most-cited journal articles and reviews published between 2004 and 2023 in the context of the blood supply chain, as retrieved from the Scopus database. The study analyzed research trends in this area and knowledge themes through a keyword co-occurrence analysis and bibliographic coupling using VOSviewer.

Findings – The study reveals that the top 100 most-cited journal articles and reviews within the domain of the blood supply chain were published between 2004 and 2023, with a notable surge in research activity observed in the recent years. Through keyword analysis, five themes, which are “inventory management and supply chain management operations for blood products,” “stochastic and possibilistic programming for designing blood supply chain network and sustainability,” “robust optimization in blood supply chain network design under uncertainty and disaster conditions,” “Network design using multi-objective, possibilistic and two-stage stochastic programming in blood supply chains” and “perishable inventory management in blood supply chains,” were obtained. On the other hand, four themes from bibliographic coupling include “designing blood supply chain networks during the time of disasters and emergencies,” “optimizing and managing blood supply chains for enhancing efficiency and reducing wastage,” “inventory management and advanced techniques in the context blood supply chain management” and “enhancing safety, efficiency and continuous blood supply in the face of various challenges.”

Originality/value – This study uniquely analyzed 100 most-cited publications in the realm of the blood supply chain, which provides relevant knowledge themes that are crucial for future studies and contributing to the knowledge in this research domain.

Keywords Blood, Blood supply chain, Supply chain management, Bibliometrics, Health, Blood products

Paper type Research paper

1. Introduction

Over the years, supply chain management (SCM) has gained growing recognition and engagement from a number of stakeholders including governmental agencies, academics, businesses and broader society (Changalima and Kimario, 2025; Fang *et al.*, 2022; Siems *et al.*, 2023; Venkataraman and Pinto, 2023). SCM has greatly advanced our understanding in several dimensions of life across various domains such as manufacturing (Khan and Emon, 2025), public service (Sienkiewicz-Małyjurek and Szymczak, 2023), healthcare (Fiore *et al.*, 2023), agriculture (Changalima and Ismail, 2022), tourism (Cheunkamon *et al.*, 2023) and food (El Ayoubi and Radmehr, 2023). In these domains, it has been articulated that the proper SCM is relevant to developing more effective solutions for tackling widespread issues facing organizations, industries and communities. This is the case because effective and efficient



SCM is crucial for enhancing organizational performance (Duong *et al.*, 2019), maximizing overall profits, managing risks and enhancing the satisfaction of relevant stakeholders in given industries such as customers. Although SCM practices span across various industries, its significance within the healthcare sector is widely acknowledged (Dixit *et al.*, 2019; Maeng *et al.*, 2018; Mwaiseje and Mwangike, 2019; Mwakyjeja and Kimario, 2024).

The blood supply chain (SC) is a crucial component of healthcare systems. Managing blood SCs is relevant to ensure the timely and safe delivery of blood products to patients (Abolghasemi *et al.*, 2025; Lusiantoro and Yates, 2021). Efficient blood SCM enhances patient survival, the effectiveness of medical treatments and other related public health outcomes (Beliën and Forcé, 2012). The nature of blood products poses challenges such as logistical inefficiencies characterized by persistent transportation issues and shortages (Karadağ *et al.*, 2021; Raykar *et al.*, 2021; Torrado and Barbosa-Póvoa, 2022), which can lead to severe consequences for healthcare systems and patients. On the other hand, studies on blood SC research offer several practical implications by addressing blood SC challenges and providing solutions that can improve operational efficiency, reduce costs and enhance the quality of care provided to patients (Agac *et al.*, 2024; Hu *et al.*, 2024; Katsaliaki *et al.*, 2014; Seyfi-Shishavan *et al.*, 2023). Furthermore, as blood SCs are complex systems involving multiple stakeholders, including hospitals, blood banks and regulatory bodies (Atcha *et al.*, 2024; Hosseinifard and Abbasi, 2018), this research domain contributes to enhancing emergency preparedness and addressing health equity and health equality concerns.

Moreover, in the context of healthcare, blood SCM has been recognized among scholars (Katsaliaki *et al.*, 2014; Maeng *et al.*, 2018). This research field is relevant for addressing the availability of safe blood products (Ghandforoush and Sen, 2010), which is important during emergencies and other medical situations such as surgeries. Since blood is the relevant product for enhancing health service delivery (Imamoglu *et al.*, 2023; Pirabán *et al.*, 2019), understanding its SCM is relevant. This is crucial, as the supply of blood is one of the vital components for having hospital operations in the first place (Maeng *et al.*, 2018). In this context, SCM entails various activities in relation to blood products, which include procurement, demand forecasting, inventory management, distribution and managing SC risks. These domains of blood SCM have attracted a number of empirical and review research in the field (Eghtesadifard and Jozan, 2022; Pirabán *et al.*, 2019; Torrado and Barbosa-Póvoa, 2022). Among the existing literature are bibliometric studies, which encompass studies that examine bibliographic scientific data from publications on given research topics.

For instance, Imamoglu *et al.* (2023) and Eghtesadifard and Jozan (2022) applied bibliometric analysis in the review of blood SC and provided a number of research directions in the field. Most bibliometric studies within this domain have thus far neglected to fully examine the contributions of influential articles and reviews to the research landscape, particularly concerning their productivity and structure. In response to this gap, the present study undertakes an analysis of the 100 most-cited publications within the field of blood SC. This investigation is conducted with the aim of addressing the following research objectives:

- (1) To identify the research trends within the publications of the top 100 most-cited articles in blood SC;
- (2) To identify the primary stakeholders, including authors, countries and journals, within the top 100 most-cited publications in blood SC;
- (3) To determine the most influential publications among the top 100 most-cited articles in blood SC and
- (4) To determine the knowledge themes from the top 100 most-cited publications in blood SC.

Considering the 100 most-cited publications, this review contributes significantly to the understanding of blood SCM research by identifying emerging trends and key research areas

within the field. This is particularly important given the crucial role that blood SCs play in healthcare systems worldwide, where efficient and reliable blood management can directly affect health-related outcomes. Despite the importance of blood SCs, there is a lack of comprehensive reviews that consolidate and synthesize influential publications. This review, by highlighting the 100 most-cited publications, not only provides a thorough analysis of the field but also serves as a valuable resource for researchers, practitioners and policymakers striving to improve blood SC systems. Furthermore, the analysis from this review, which is based on citation trends, offers insights into the impact of various studies, helping to identify which research areas are gaining prominence and which issues remain underexplored. The inclusion of these highly cited works fulfills the need to assess the influence of blood SC research within both the healthcare and SCM domains, ultimately bridging gaps in knowledge and guiding future research efforts.

The remaining sections of this article are divided into four parts. The next section presents the methodology of the study in which the section provides relevant information regarding the selection procedure of publications that were involved in the analysis. Then, after methodology, the study presents the main results and discussion in relation to analyzed data as retrieved from the Scopus database. Then conclusion is provided which includes some implications based on the main findings. Lastly, the study presents limitations and directions for future research.

2. Methodology

This study employs a bibliometric analysis to analyze the retrieved data to meet the research objectives. Bibliometric analysis serves as a quantitative technique for analyzing and summarizing key findings across a collection of documents (Ndiango *et al.*, 2025). Thus, a technique is relevant in examining research trends, publications, impact and knowledge themes in a given set of data as retrieved from databases (Donthu *et al.*, 2021). The study utilized a combination of bibliometric analysis techniques, including citation analysis, co-occurrence analysis and bibliographic coupling, to fulfill the research objectives. The researcher conducted a search in the Scopus database on 5th December 2024. Scopus was involved in this study as it is considered a relevant database with a number of quality indexed journals (Changalima, 2025). Additionally, Scopus has been widely recognized as a relevant database due to its comprehensiveness and breadth, offering access to a vast range of peer-reviewed journals across various disciplines (Singh *et al.*, 2021). Scopus is recognized for its rigorous indexing criteria, ensuring that only high-quality, credible publications are included, which further strengthens its reputation as one of the most reliable databases for academic research (Baas *et al.*, 2020).

In this case, Scopus was involved to search documents that are centering on blood SC. The search strategy includes a combination of “blood” AND (“supply chain*” OR “supply chain management”), which was done within “article title, abstract and keywords” to obtain only the relevant documents in the realm of blood SC (see Figure 1). The search was conducted without restricting the publication year to comprehensive capture all relevant publications up to the date of the search. This search yielded 894 documents that were published between 2001 and 2024. Based on the inclusion criteria, the search was limited only to “journal” as a document source. This yielded 677 documents after removing 217 documents. The search also resulted in 644 documents after limiting it to “article” and “review” only. Therefore, 33 documents which were not classified as journal articles or reviews were excluded from the analysis. This was deliberately done, as articles and reviews from journals are frequently subjected to rigorous peer reviews, and hence, these published documents are considered of high quality (Changalima and Mchopa, 2024).

To maintain the focus of the current study, the search was limited to only publications, which were in the *final* publication stage, resulting in 630 documents. Furthermore, as English is the common international language for publication in the Scopus database, the search was further limited to documents that are published in English, and hence, 12 documents that were

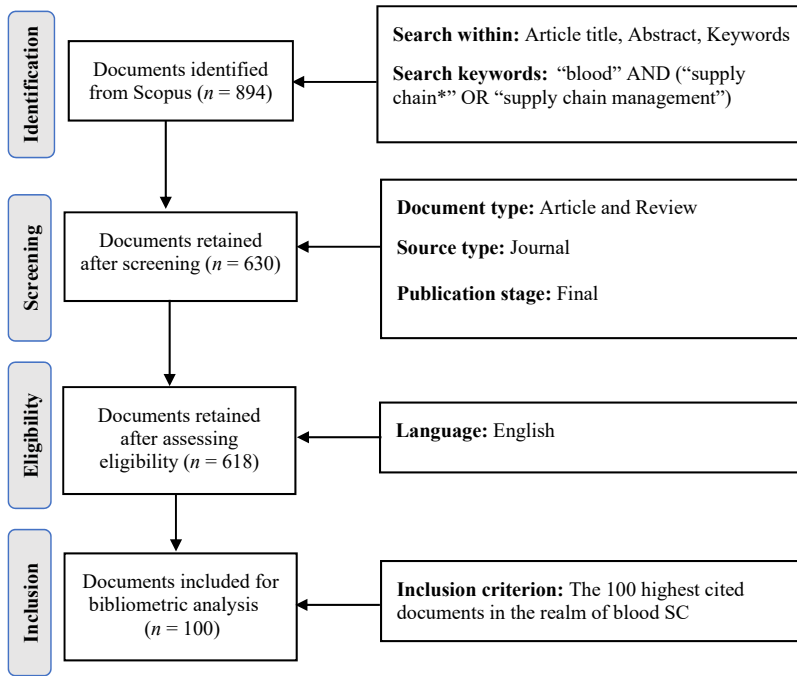


Figure 1. The selection procedure. **Source:** Figure by the author

published in non-English languages were removed, and 618 documents were retained after meeting this criterion (eligibility). Lastly, the study included only 100 most-cited documents, which were obtained after the documents in the search were sorted in a range of citations from highest to lowest. This was done to meet the focus of the current study as the study aims to conduct bibliometric analysis on the 100 most-cited publications in the realm of blood SC. To ensure that only relevant publications are included in the final dataset, the relevance of publications was checked based on the information presented in the *abstract*. This was done because studies that include the words *blood* and *supply chain* in the title, abstract or keywords could be based on other domains of healthcare research. Therefore, in this stage, only documents that delve into the realm of blood SC in different aspects were considered for inclusion. Finally, the final obtained dataset that included only 100 most-cited publications was involved in the analysis.

3. Results and discussion

3.1 The publication trends

Overall, the dataset included 100 documents, which were categorized as the most-cited publications in the domain of blood SC. These documents were published between 2004 and 2023. Therefore, the findings in [Figure 2](#) show the number of documents (most-cited) that were published over a range of years between 2004 and 2023. The information reveals some interesting trends and fluctuations in the documents published in the context of blood SC. The findings show that between 2004 and 2008, there was a consistent presence of only one document in a given year that received the most citations (see year 2004, 2006 and 2008). The period was also characterized by the absence of most-cited publications in some years. This suggests a relatively stable and very low productivity for the most-cited publications during



Figure 2. The publication trends. **Source:** Figure by the author

that period. However, in 2009, there was a notable increase to three publications. This could indicate a growing interest in the research related to blood SC in the context of the most-cited documents. On the other hand, the year 2010 saw a decline, with the number of publications dropping back down to one. While in 2011 and 2012, there was an increase in the number of publications, reaching four and five, respectively.

The interest in most-cited documents was particularly evident between 2013 and 2017. Despite fluctuations in the number of documents published during these years, a total of 24 documents were produced, with 2 published in 2013 and 9 in 2017. This pattern indicates a certain instability in the most-cited publications within the domain of blood SCs. Particularly, following the year 2017, which saw nine most-cited publications, research productivity continues to grow and reached its highest peak in 2020, with 16 publications. Thus, it can be stated that research productivity for the most-cited publications became more noteworthy from the year 2017 onward. The findings in [Figure 2](#) demonstrate a significant contribution to research productivity for the most-cited publications from 2017 to 2022, with a total of 67 documents produced. Compared to earlier years, this period experienced remarkable growth, which may be attributed to increased interest in the research landscape. Furthermore, the findings indicate that publications from these years garnered the most attention from scholars within the research domain. Generally, the findings highlight fluctuations in terms of the number of most-cited documents over the years, suggesting dynamic and evolving research interests in the realm of blood SC. It should be noted that the decline in the number of most-cited publications in recent years could be attributed to the age of publications, as the study focused only on the 100 most-cited publications in the context of the blood SC.

3.2 The most active authors, countries and journals

The study analyzes the information regarding the most active authors, countries and journals in the research domain of blood SC for the 100 most-cited articles. The results in [Table 1](#) reveal that “Hosseini-Motlagh, S.M.” with 10 publications is the most active author in the 100 most-cited documents from the Scopus database, while the *Annals of Operations Research* is the most active journal for the 100 most-cited publications with nine documents in the topic of blood SC. On the other hand, Iran is the leading country in research productivity in the most-cited journal publications on the topic of blood SC, with 42 publications. The remaining active stakeholders for publications in this topic are presented in [Table 1](#), providing pertinent information for assessing research productivity in terms of the number of documents (most cited) published in the domain of blood SC.

Table 1. The most active authors, countries and journals

Authors	Documents	Countries	Documents	Journals	Documents
Hosseini-Motlagh, S.M.	10	Iran	42	<i>Annals of Operations Research</i>	9
Abbasi, B.	6	USA	27	<i>Computers and Industrial Engineering</i>	8
Samani, MR.G.	6	United Kingdom	14	<i>Transportation Research Part E: Logistics and Transportation Review</i>	7
Brailsford, S.C.	4	Canada	11	<i>International Journal of Production Economics</i>	6
Diabat, A.	4	Australia	9	<i>Computers and Operations Research</i>	6
Khalilpourazari, S	4	France	5	<i>Socio-Economic Planning Sciences</i>	5
Osorio, A.F.	4	Colombia	5	<i>Applied Mathematical Modelling</i>	4
Smith, H.K.	4	Germany	5	<i>Transfusion</i>	3
Tavakkoli-Moghaddam, R.	4	United Arab Emirates	5	<i>Vox Sanguinis</i>	3

Source(s): Table by the author

Based on the findings in [Table 1](#) it is crucial to understand the relevant active stakeholders in the research domain of blood SC. The second objective of this study relied on identifying the most active authors, countries and journals. Understanding the relevant active authors, countries and journals in blood SC research, particularly for the most-cited publications, is relevant for gaining insights into the most active contributors in the most-cited journal publications. Identifying active authors in this context helps pinpoint key researchers driving the blood SC field forward, while examining the countries involved reveals regional research strengths in research productivity for the most-cited publications. Additionally, identifying the leading journals allows for a clearer understanding of where the most impactful research is being published. This knowledge is essential for staying updated on groundbreaking advancements within the field of blood SC.

3.3 Most influential publications

This study analyzed the 100 most-cited journal publications on the topic of blood SC. These publications accumulated a total of 7,764 citations, with an average of 77.64 citations per document. The results in [Table 2](#) present only 10 publications, which are regarded as the most influential journal publications from the 100 most-cited publications. It should be noted that out of the total 7,764 citations, 1975 (25.44%) citations are attributed to the 10 journal articles and reviews presented in [Table 2](#). Therefore, [Table 2](#) presents the most influential articles on the research topic of blood SC.

The work by [Beliën and Forcé \(2012\)](#) stands out with a total of 335 citations and is regarded as the most influential publication in this domain, followed by the publication by [Jabbarzadeh et al. \(2014\)](#) with a total of 304 citations. [Beliën and Forcé \(2012\)](#) have the highest citation count, primarily due to their comprehensive examination of the literature concerning the inventory and SCM of blood products. Within their investigation, various methodologies were employed to classify the encompassed published works, including categorization based on distinct types of blood products and classification was conducted utilizing solution methods, among others. Their review holds relevance within the research domain, as it establishes a foundation for tracing previously published works in the area, identifying prevalent trends and

Table 2. Most influential publications

S/N	Authors and year	Title	Journal	Cites	Cites/ Year	Age
1	Beliën and Forcé (2012)	Supply chain management of blood products: A literature review	<i>European Journal of Operational Research</i>	335	27.92	12
2	Jabbarzadeh et al. (2014)	Dynamic supply chain network design for the supply of blood in disasters: A robust model with real world application	<i>Transportation Research Part E: Logistics and Transportation Review</i>	304	30.4	10
3	Fahimnia et al. (2017)	Supply chain design for efficient and effective blood supply in disasters	<i>International Journal of Production Economics</i>	206	29.43	7
4	Williamson and Devine (2013)	Challenges in the management of the blood supply	<i>The Lancet</i>	200	18.18	11
5	Dillon et al. (2017)	A two-stage stochastic programming model for inventory management in the blood supply chain	<i>International Journal of Production Economics</i>	178	25.43	7
6	Osorio et al. (2015)	A structured review of quantitative models in the blood supply chain: A taxonomic framework for decision-making	<i>International Journal of Production Research</i>	176	19.56	9
7	Nagurney et al. (2012)	Supply chain network operations management of a blood banking system with cost and risk minimization	<i>Computational Management Science</i>	162	13.5	12
8	Zahiri and Pishvae (2017)	Blood supply chain network design considering blood group compatibility under uncertainty	<i>International Journal of Production Research</i>	152	21.71	7
9	Gunpinar and Centeno (2015)	Stochastic integer programming models for reducing wastages and shortages of blood products at hospitals	<i>Computers and Operations Research</i>	139	15.44	9
10	Diabat et al. (2019)	A perishable product supply chain network design problem with reliability and disruption considerations	<i>International Journal of Production Economics</i>	123	24.6	5

Source(s): Table by the author

delineating areas for future research. Their work has garnered citations, including from other influential publications in the research field such as [Dillon et al. \(2017\)](#), [Fahimnia et al. \(2017\)](#), [Ramezani and Behboodi \(2017\)](#) and [Zahiri and Pishvae \(2017\)](#). This demonstrates that [Beliën and Forcé \(2012\)](#) is the most influential publication in the realm of blood SC.

With 206 citations, [Fahimnia et al. \(2017\)](#) designed SC strategies for efficient and effective blood supply during disasters, emphasizing the importance of rapid response and resource allocation. The work by [Williamson and Devine \(2013\)](#) has 200 citations. This paper discusses the challenges in managing blood supply, while [Dillon et al. \(2017\)](#) introduce a two-stage stochastic programming model aimed at optimizing inventory management within the blood SC. This is relevant in addressing uncertainties in the demand and supply of blood products. [Osorio et al. \(2015\)](#), with 176 citations, provide a structured review of quantitative models in

the blood SC, offering a taxonomic framework for decision-making processes across various blood SC challenges. [Nagurney et al. \(2012\)](#) investigate blood banking system operations through an SC network perspective, while [Zahiri and Pishvaei \(2017\)](#) design a blood SC network that accounts for blood group compatibility while considering the impact of uncertainties. [Gunpinar and Centeno \(2015\)](#) present stochastic integer programming models to mitigate blood product wastages and shortages at hospitals. This is crucial for emphasizing the importance of optimal resource allocation in the context of blood SC. Lastly, with 123 citations, [Diabat et al. \(2019\)](#) examine a perishable product SC network design problem, incorporating reliability and disruption considerations to improve the resilience and efficiency of the blood SC.

3.4 Knowledge themes

3.4.1 Keyword analysis (co-word analysis). The co-word analysis was conducted using VOSviewer, based on the assumption that when two or more author keywords representing a specific research topic appear together in the publication, they possess essential relationships ([Changalima and Mchopa, 2024](#); [Donthu et al., 2021](#); [Lozano et al., 2019](#)). The unit of analysis was “author keyword,” and the criterion that necessitates a minimum of three occurrences of a keyword was applied, leading to the identification of 30 items. These items were then categorized into five clusters. The clusters are presented in [Table 3](#) and [Figure 3](#) with different colors and sizes of nodes presenting the occurrences and strength. “Blood supply chain” is the most prominent topic, with 55 occurrences and 56 total link strength, which signifies the focus of this research. Blood SC as a crucial area of investigation is relevant to the current topic and hence justifies the most occurrence of this keyword from the included publications.

The first cluster (red) is the largest, with 10 keywords that center on “inventory management and SCM operations for blood products.” The theme presents topics that provide the relevance of operations related to inventory management in the context of blood SCs. Within the red cluster, the most-occurred keywords are “supply chain management” and “inventory management,” with nine and eight occurrences, respectively. These topics signify the relevance of SCM and inventory management operations in the context of blood products. Other occurred keywords are “blood collection,” “blood products” and “blood transfusion.” These topics emphasize the relevance of blood collection and handling of blood products to ensure timely blood transfusion for patients. Studies such as [Liu et al. \(2021\)](#) present the relevance of proper management of blood products in the SCs. Blood is considered a perishable product, and hence, proper management is crucial due to its limited shelf life ([Abbasi and Hosseinifard, 2014](#)). On the other hand, “lateral transshipment” is among the common topics in the context of blood SC. [Larimi et al. \(2019\)](#) present intriguing information regarding the impact of medical centers’ lateral transshipment, taking into account the perishable nature of blood products and transshipment costs. Additionally, [Dehghani and Abbasi \(2018\)](#) commented that lateral transshipment is a valuable strategy aimed at enhancing SC performance, especially for perishable products. The cluster further supports efforts geared towards the optimization of blood SC operations, which could also be done through simulation models. This is relevant as optimizing blood SC operation enhances the efficiency of the blood supply process and reduces waste ([Osorio et al., 2018](#)). This could be effectively done through simulation models that predict and plan the most efficient ways to handle and distribute blood products ([Osorio et al., 2017](#)).

The second cluster (green) with eight items centers on “stochastic and possibilistic programming for designing blood SC network and sustainability.” The theme is relevant in the research landscape as it provides crucial insights regarding the application of advanced modeling techniques such as robust possibilistic programming and stochastic programming to design resilient SCs that can adapt to uncertainty and ensure timely operations in aspects of blood products ([Dehghani et al., 2021](#); [Dillon et al., 2017](#); [Zahiri et al., 2015, 2018](#)). On the other hand, studies that focus on this theme regard the topic of “blood banking” such as [Arvan](#)

Table 3. Clusters and themes form keyword co-occurrence analysis

Cluster/Theme	Keywords	Occurrences	Total link strength
Cluster 1 (red): Inventory management and SCM operations for blood products	Blood collection	3	7
	Blood products	5	11
	Blood transfusion	3	6
	Inventory management	8	15
	Lateral transshipment	4	6
	Optimization	4	12
	Perishable inventory	3	8
	Simulation	5	12
	Supply chain	5	8
Cluster 2 (green): Stochastic and possibilistic programming for designing blood SC network and sustainability	Supply chain management	9	15
	Blood banking	4	5
	Blood supply chain network	3	3
	Healthcare	3	5
	Perishable products	5	10
	Robust possibilistic programming	3	5
	Stochastic programming	6	15
	Supply chain design	3	5
	Sustainability	3	6
Cluster 3 (blue): Robust optimization in blood SC network design under uncertainty and disaster conditions	Disaster	6	13
	Lagrangian relaxation	3	9
	Multi-objective optimization	4	10
	Robust optimization	12	23
	Supply chain network design	5	14
	Uncertainty	11	22
Cluster 4 (yellow): Network design using multi-objective, possibilistic and two-stage stochastic programming in blood SCs	Multi-objective programming	4	8
	Network design	3	8
	Possibilistic programming	3	7
	Two-stage stochastic programming	3	9
	Blood supply chain	45	69
Cluster 5 (purple): Perishable inventory management in blood SCs	Perishable inventory management	3	2

Source(s): Table by the author

[et al. \(2015\)](#) design a bi-objective, multi-product SC network for blood supply, aiming to optimize both costs and distribution efficiency in blood banking systems. The paper focuses on improving the overall performance of blood supply networks by balancing these two objectives. Similarly, [Nagurney et al. \(2012\)](#) explore SC network operations in blood banking. The study emphasizes minimizing both cost and risk in the context of blood SCs. Other studies such as [Mousavi et al. \(2021\)](#), [Eskandari-Khanghahi et al. \(2018\)](#) and [Jemai et al. \(2020\)](#) address the topic of “sustainability,” which revolves around designing and optimizing blood SCs. Therefore, the studies pinpoint the relevance of balancing sustainability aspects (environmental, social and economic) to develop sustainable and resilient blood SCs.

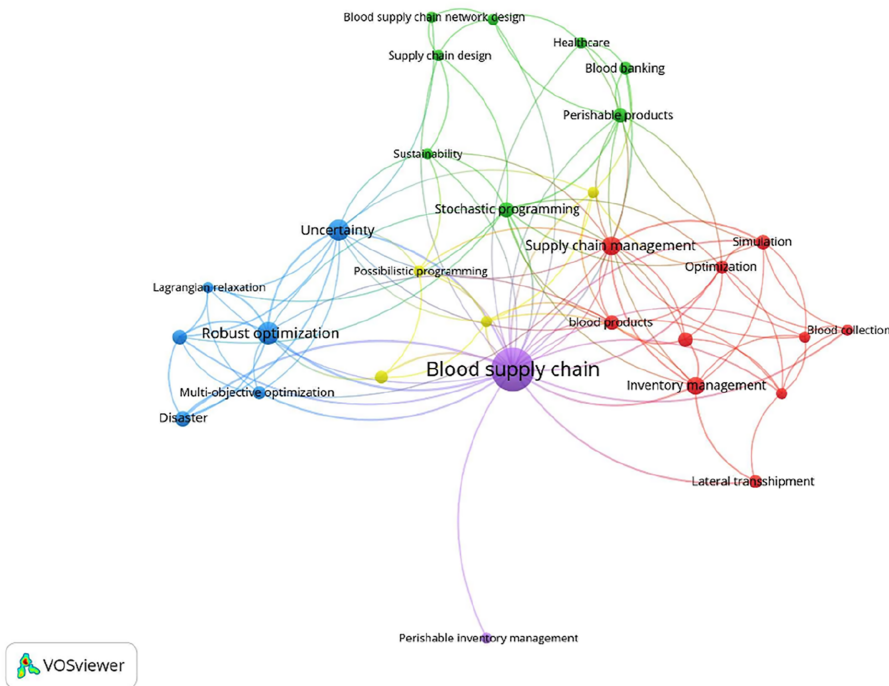


Figure 3. Network of author keywords on blood SC. **Source:** Figure by the author

Cluster 3 (blue) includes six keywords that center on “robust optimization in blood SC network design under uncertainty and disaster conditions.” The cluster encompasses topics such as “robust optimization” and “uncertainty,” which have 12 and 11 occurrences, respectively. Other topics including “multi-objective optimization,” “Lagrangian relaxation” and “disaster” reflect the utilization of advanced optimization techniques to improve the management and efficiency of the blood SCs specifically during times of crisis or disasters. Studies on this theme include those that address green aspects of blood SCs by considering robust optimization (Heidari-Fathian and Pasandideh, 2018; Razavi *et al.*, 2021) and other techniques such as Lagrangian relaxation in addressing emergency situations that are linked with disruptions and disasters (Fazli-Khalaf *et al.*, 2019; Haghjoo *et al.*, 2020; Hamdan and Diabat, 2020; Hosseini-Motlagh *et al.*, 2020; Jabbarzadeh *et al.*, 2014; Rahmani, 2019).

The fourth cluster (yellow) has four keywords, which include “multi-objective programming” with four occurrences and “network design,” “possibilistic programming” and “two-stage stochastic programming” with three occurrences each. These topics revolve around “network design using multi-objective, possibilistic and two-stage stochastic programming in blood SCs” as a common theme. The theme is relevant in the domain of blood SCM as it presents relevant advanced mathematical techniques used to address the complexities of managing blood SCs, which are characterized by conflicting objectives and long-term planning. The cluster is well presented with existing studies such as Khalilpourazari *et al.* (2020) and Samani *et al.* (2019). Samani *et al.* (2019) propose a multi-objective model for blood SC design, integrating both quantitative factors and qualitative criteria, while Khalilpourazari *et al.* (2020) consider multi-objective programming when designing an efficient blood SC network in times of crisis. Their research addresses the optimization of blood SCs, focusing on disaster scenarios like earthquakes. Other studies such as Zahiri *et al.*

(2015) highlight the use of possibilistic programming to model uncertainties in SCs when precise probability distributions are unavailable, providing a flexible approach to handling imprecise information. This is crucial in decision-making in the context of blood SCM. Salehi *et al.* (2019) extend this by utilizing two-stage stochastic programming to optimize blood SC decisions under uncertainty. Their approach is better for dynamic adaptation, crucial in crisis scenarios like earthquakes, where demand and supply can fluctuate unpredictably.

The last cluster (purple) is the smallest, with only two keywords, “blood supply chain” and “perishable inventory management.” The cluster delves into a theme of “perishable inventory management in blood SCs.” The theme is relevant in the research landscape as it presents crucial aspects of blood SCM, which is perishable inventory management within the context of blood SC. The occurrence of these two topics within this theme signifies the critical challenge of managing the perishable nature of blood products in inventory systems, especially within blood SCs. Blood products have a limited shelf life, which necessitates precise and efficient inventory management to prevent waste and ensure that supplies are available when needed. This perishability adds complexity to blood SC operations, requiring sophisticated forecasting, real-time monitoring and responsive distribution strategies. The cluster includes some relevant studies that explore the key advancements in managing perishable inventory systems with a focus on blood products. For instance, Abbasi and Hosseini *et al.* (2014) highlight the challenges in blood bank inventory management, emphasizing a modified FIFO policy to optimize the age of issued blood units, minimize shortages and outdated and outperform traditional FIFO and LIFO policies. On the other hand, Abbasi *et al.* (2020) propose a machine learning-based approach to improve operational decisions in resource-constrained settings, showing significant cost reductions in hospital blood unit transshipment when machine learning models replicate solutions derived from stochastic optimization models. Also, Zhou *et al.* (2011) examine platelet inventory management, presenting an optimal replenishment policy combining regular and expedited orders to minimize costs.

3.4.2 Bibliographic coupling. Bibliographic coupling is a method that categorizes publications into thematic groupings by identifying shared references, making it most effective when applied within a defined scope (Donthu *et al.*, 2021; Zupic and Cater, 2015). This study employed bibliographic coupling in VOSviewer to generate knowledge themes on the research landscape. Clusters were specifically derived through bibliographic coupling analysis, with a minimum criterion of 80 citations required for a document to be included in the analysis. This process yielded 35 items, which were then linked into 4 distinct clusters (see Table 4 and Figure 4).

Cluster 1 (red) is the biggest cluster, with 14 publications that center on “designing blood SC networks during the time of disasters and emergencies.” This theme is crucial in the realm of blood SCM, as SC networks serve to illustrate the interconnections among SC members, explaining both organizational interactions and the transmission of information and materials between them. The cluster includes most of the studies that address the concerns linked to blood SCM in disasters. For instance, Fahimnia *et al.* (2017) explore SC design strategies for efficient and effective blood supply during disasters, emphasizing the importance of rapid response and resource allocation. Salehi *et al.* (2019) focus on designing emergency blood SC networks. Additionally, based on data obtained from Iran (one of the most earthquake-prone countries in the world), Habibi-Kouchaksaraei *et al.* (2018) consider the designing of robust blood SC in the event of a disaster. Furthermore, other studies employed Lagrangian relaxation in the robust design of blood SCs under disruptions (Hamdan and Diabat, 2020). On the other hand, Hamadneh *et al.* (2021) emphasize that SC visibility plays a crucial role in blood SCM, particularly in ensuring the efficient flow of blood products to respond effectively during emergencies and shortages. Heidari-Fathian and Pasandideh (2018) present a model for designing a green-blood SC network, which considers different blood types and their respective shelf lives. This study is relevant to the theme as it accounts for the uncertainties in both the demand and supply of blood products. Zahiri *et al.* (2015) highlight the challenges posed by uncertainty in decision-making related to blood SCs, particularly in managing blood

Table 4. Clusters and themes from bibliographic coupling

Cluster/Theme	References	Citations	Total link strength
Cluster 1 (red): Designing blood SC networks during the time of disasters and emergencies	Diabat et al. (2019)	123	152
	Eskandari-Khanghahi et al. (2018)	121	179
	Fahimnia et al. (2017)	206	90
	Samani et al. (2018)	99	174
	Habibi-Kouchaksaraei et al. (2018)	88	94
	Haghjoo et al. (2020)	88	108
	Hamadneh et al. (2021)	114	39
	Hamdan and Diabat (2020)	112	244
	Heidari-Fathian and Pasandideh (2018)	87	93
	Jabbarzadeh et al. (2014)	304	134
	Khalilpourazari and Khamseh (2019)	94	134
	Salehi et al. (2019)	91	140
	Zahiri et al. (2015)	93	116
	Zahiri and Pishvaei (2017)	152	122
Cluster 2 (green): Optimizing and managing blood SCs for enhancing efficiency and reducing wastage	Beliën and Forcé (2012)	335	228
	Duan and Liao (2014)	111	115
	Ghandforoush and Sen (2010)	106	20
	Gunpinar and Centeno (2015)	139	245
	Nagurney et al. (2012)	162	109
	Osorio et al. (2015)	176	395
	Osorio et al. (2017)	84	137
	Ryttilä and Spens (2006)	104	29
	Stanger et al. (2012)	101	95
	Zhou et al. (2011)	115	61
	Abbasi et al. (2020)	86	22
	Dillon et al. (2017)	178	219
	Hamdan and Diabat (2019)	119	147
	Hosseiniifard and Abbasi (2018)	113	74
Cluster 3 (blue): Inventory management and advanced techniques in the context of blood SCM	Pirabán et al. (2019)	107	292
	Rajendran and Ravindran (2019)	81	109
	Ramezani and Behboodi (2017)	115	172
	Salunkhe et al. (2015)	93	1
	Seifried et al. (2011)	90	3
Cluster 4 (yellow): Enhancing safety, efficiency and continuous blood supply in the face of various challenges	Williamson and Devine (2013)	200	18
	Zahiri et al. (2018)	94	218

Source(s): Table by the author

collection. Studies within this cluster aim to enhance the smooth movement of blood products, particularly during times of disasters or emergencies, while also considering existing uncertainties ([Diabat et al., 2019](#); [Eskandari-Khanghahi et al., 2018](#); [Haghjoo et al., 2020](#)).

The second cluster (green) centers on “optimizing and managing blood SCs for enhancing efficiency and reducing wastage.” This theme presents relevant aspects of some challenges

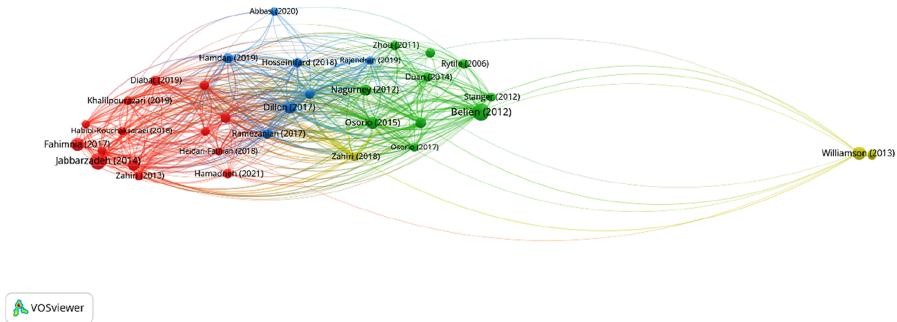


Figure 4. Network analysis from bibliographic coupling. **Source:** Figure by the author

facing blood products in blood SCs such as perishability, which requires proper attention. Existing studies show the application of techniques such as simulation, optimization and decision support systems (Duan and Liao, 2014; Ghandforoush and Sen, 2010; Ryttilä and Spens, 2006) to improve production planning, forecasting and inventory control to reduce waste and prevent shortages (Gunpinar and Centeno, 2015). Additionally, the incorporation of cost and risk minimization models is a recurrent focus to improve operational efficiency and ensure resilience in the face of fluctuating demand (Nagurney *et al.*, 2012; Osorio *et al.*, 2015). Other studies emphasize the need for efficient inventory policies to reduce wastage and shortages while maintaining optimal stock levels (Gunpinar and Centeno, 2015; Stanger *et al.*, 2012; Zhou *et al.*, 2011). Osorio *et al.* (2017) highlight simulation-optimization models for production planning in blood SCs. With most of the presented evidence, the theme remains significant in enhancing blood SCs to effectively and efficiently meet the demand for blood products.

The third cluster (blue) is on “inventory management and advanced techniques in the context of blood SCM.” This theme is relevant in the domain of blood SCM, as inventory management and the application of advanced techniques in managing blood products within SCs enhance the timely, efficient and safe delivery of blood products to meet medical demands while minimizing waste and shortages. Some studies investigate the impacts of inventory centralization on the sustainability of the blood SC (Hosseini and Abbasi, 2018), while others focus on minimizing platelet wastage and shortage through improved inventory strategies (Rajendran and Ravindran, 2019). These two studies emphasize the relevance of inventory management within blood SCs. On the other hand, several of these papers explore advanced techniques such as stochastic programming, multi-echelon models and machine learning to enhance blood SC operations. For instance, Dillon *et al.* (2017) proposed the application of a two-stage stochastic technique to enhance inventory management within blood SCs. This study offers pertinent insights as the blood SC is marked by demand uncertainties and the perishable nature of blood products. Abbasi *et al.* (2020) consider the case of blood SCM and propose an approach for addressing the challenge of solving large operational stochastic optimization problems by utilizing machine learning models. This cluster includes several studies that demonstrate the importance of advanced models and algorithms to manage blood SCs to ensure a reliable and sustainable supply of blood, even under uncertainty and varying demand conditions (Abbasi *et al.*, 2020; Dillon *et al.*, 2017; Hamdan and Diabat, 2019; Pirabán *et al.*, 2019; Ramezani and Behboodi, 2017).

The fourth cluster (yellow) is based on “enhancing safety, efficiency and continuous blood supply in the face of various challenges.” This theme is relevant, as there are several challenges and related factors affecting the blood supply. This is crucial in the context of the blood SC due to the inherent nature of blood demand and supply, which heightens the vulnerability of the blood SC. The cluster has four studies, which address specific issues in the general theme of

ensuring a safe, efficient and continuous blood supply. The cluster includes four publications, which address the research theme in the face of various demographic, technological and logistical factors. [Salunkhe et al. \(2015\)](#) focus on pathogen reduction treatments and the need for advancements in transfusion safety. The paper presents insights into the reduction of transfusion-transmitted infections through several measures institutionalized in every step of the blood SC (collection, processing and storage). Their study shows the existing efforts in minimizing the risk of infections associated with blood transfusions, which directly ties into the broader issue of blood safety. Other studies highlight the increasing demand for blood products due to aging populations and the necessity for innovative blood management practices, such as donor recruitment, bloodstock optimization and personalized medicine ([Seifried et al., 2011](#); [Williamson and Devine, 2013](#)). Lastly, a study by [Zahiri et al. \(2018\)](#) presents a logistical approach to optimizing the blood SC to manage perishability and uncertainty in donation and demand. The study adds to the body of blood SCM literature by proposing a stochastic programming approach for blood SC planning to optimize blood distribution and inventory management.

4. Conclusion

This study employed bibliometric analysis to fulfill its research objectives, analyzing publication productivity by examining publication trends in the 100 most-cited journal articles and reviews in the field of blood SC. Moreover, the study established knowledge themes through keyword analysis and bibliographic coupling techniques. In terms of its first contribution, the study concludes that the 100 most-cited publications were produced between 2004 and 2023, revealing significant fluctuations in productivity. The publication trends depict a dynamic and evolving landscape in research interests within the realm of blood SC for the most-cited publications. Also, the study establishes that Hosseini-Motlagh, S.M., with 10 publications, is recognized as one of the most active authors in the field of blood SC research for the most-cited publications. The *Annals of Operations Research*, with nine publications, stands out as a prominent journal outlet for the most-cited publications. Additionally, Iran is noted as a significant contributor with 42 publications.

Regarding knowledge themes, the study identified five themes through keyword analysis and an additional four themes through bibliographic coupling. The first set of themes that were derived from five distinct clusters obtained from co-word analysis includes:

- (1) Inventory management and SCM operations for blood products;
- (2) Stochastic and possibilistic programming for designing blood SC network and sustainability;
- (3) Robust optimization in blood SC network design under uncertainty and disaster conditions;
- (4) Network design using multi-objective, possibilistic and two-stage stochastic programming in blood SCs; and
- (5) Perishable inventory management in blood SCs.

The second set of themes, which were derived from four distinct clusters obtained from bibliographic coupling, includes:

- (1) Designing blood SC networks during the time of disasters and emergencies;
- (2) Optimizing and managing blood SCs for enhancing efficiency and reducing wastage;
- (3) Inventory management and advanced techniques in the context of blood SCM; and
- (4) Enhancing safety, efficiency and continuous blood supply in the face of various challenges.

These themes are relevant in the realm of blood SCM for practitioners, policymakers and academics. First, practitioners could benefit from understanding how the blood SC operates to enhance the efficient and smooth flow of blood products, which is relevant in the healthcare industry. This is relevant because, through insights from different studies such as simulation studies on the blood SC (Osorio *et al.*, 2017; Salehi *et al.*, 2019), practitioners can identify best practices and innovative approaches to improve efficiency and streamline operations. This may include optimizing transportation routes, enhancing inventory management systems or implementing new technologies for tracking and monitoring blood products. Additionally, policymakers can utilize the insights gleaned from these themes to formulate informed decisions pertaining to resource allocation, investment priorities and strategic planning within the realm of blood SCM. For instance, an understanding of robust optimization and stochastic programming methodologies during times of crisis can facilitate the development of contingency plans to address emergency scenarios effectively.

Moreover, this study holds relevance in delineating future avenues for research, thereby guiding academic endeavors. Scholars can utilize the identified themes to direct their research efforts and prioritize areas that warrant investigation. Besides, one particularly intriguing avenue of exploration revolves around the integration of cutting-edge technologies, notably artificial intelligence (AI) and blockchain, to streamline the blood SC operations. This area is relevant as it is under-researched in the existing literature and could serve as a valuable focus for further studies. AI-driven models could be crafted to tackle the complexities of supply-demand dynamics, facilitating effective management of blood resources across supply chains. This is crucial, as blood is regarded as a necessary resource. Given the existing gaps and challenges in managing blood products and blood SCM, research on AI-driven models for the effective and efficient management of blood products will add significant value to the field. Furthermore, in the realm of academia, this study can serve as a foundational resource for designing curricula pertinent to blood SCM, operations research and healthcare logistics, especially within higher education settings. Educators can integrate the knowledge encapsulated within the various themes to enrich teaching materials, incorporating relevant topics and case studies to furnish students with a comprehensive understanding of blood SC dynamics and associated challenges.

5. Limitations and future research

Despite successfully assembling and analyzing the most-cited publications to identify trends and knowledge themes in the realm of blood SC, the study has some limitations worth noting. First, it focused exclusively on the most-cited journal articles and reviews from the Scopus database, potentially overlooking other valuable sources such as books and conference proceedings, as well as publications, which are not in the list of 100 most-cited publications. Additionally, one international database was involved (Scopus), and hence, documents from other databases were not considered. Given these limitations, future studies may benefit from expanding the scope by considering broader parameters and incorporating other sources of publications beyond journal articles and reviews and the inclusion of other international databases. Moreover, the limitation of including only the top 100 most-cited articles and reviews may impact the overall sample representation in the research domain, and hence, there is a need for further expansion and inclusion of more relevant articles regardless of citation count.

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