



Intellectual structure and trends in the humanitarian operations field

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Abstract

Humanitarian Operations (HO) have attracted the interest of professionals and academics, mainly due to their potential to reduce human suffering in disaster situations, leading to consolidation as a research field. With the evolution of the HO research field, synthesis of the knowledge and previous discoveries has become an important task for its advancement. In this study, a literature review based on bibliometric mapping techniques was carried out in order to identify the HO intellectual structure. As main results, we visually present the general emerging structure of the HO field using the VOS viewer software to devise the networks of the principal articles. The seminal research in this field is organized into two clusters: Humanitarian Supply Chain Management, and Distribution Optimization in Humanitarian Logistics. Regarding the emerging intellectual structure, three clusters were identified: Relationship Management and Big Data, Healthcare facility location, and Network flow restoration optimization. Finally, some gaps and questions for future research are presented.

Keywords Humanitarian operations · Humanitarian supply chains · Humanitarian logistics · Bibliometric methods · Scientific mapping · Disasters

1 Introduction

The UN/ISRD (2015, p. 11) defines a disaster as “a serious disruption of the functioning of a community or a society due to hazardous events interacting with conditions of vulnerability and exposure, leading to widespread human, material, economic and environmental

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losses and impacts”. In the last four decades (1980–2020), the occurrence of natural disasters (such as floods, droughts and earthquakes) and man-made ones (such as terrorist attacks, conflicts, refugee crises, and industrial accidents) is increasing and affecting communities and nations around the world, and forecasts suggest that this trend will continue (Besiou & Van Wassenhove, 2015; Kovács & Spens, 2009; Leiras et al. 2014). Confirming this understanding, the World Bank (2020) reports that, from 1980 to 2020, more than two million people and more than \$3 trillion were lost due to disasters caused by natural hazards, the total damage increasing from \$23 billion per year in the 1980s to \$150 billion a year in the last decade. Another current concern is the devastating effects that epidemics and pandemics, such as the coronavirus outbreak (COVID-19), can cause to society, disrupting everything from daily life to worldwide supply chains (Queiroz et al., 2020).

When a disaster happens, it is necessary to send humanitarian operations teams to provide relief to those affected, as well as to deliver basic resources necessary for survival, such as water, food, shelter and clothing (Van Wassenhove, 2006). This means that improving these humanitarian operations can make the difference between life and death for disaster survivors (Day et al., 2012). For this reason, the field of humanitarian operations (HO) studies, including humanitarian supply chains (HSC) and humanitarian logistics (HL), has attracted attention from both academics and practitioners (Beamon & Kotleba, 2006; Kovács and Tatham, 2009; Kovacs and Spens, 2010; Kovács and Spens, 2011; Oloruntoba et al., 2018; Altay et al., 2018; Dubey et al., 2019a), leading to a significant increase in research and publications on the topic (Jabbour et al., 2019; Fosso-Wamba, 2020). Accompanying this increase in interest in HO, there have been some significant literature reviews in the area, as will be shown. Altay and Green (2006) conducted a literature review on the application of OR/MS techniques in disaster operations management, focusing on the classification of this literature. Kovács and Spens (2007) developed a literature review focusing on humanitarian logistics, describing their restrictive operational characteristics and recognizing the possibility of cross-learning between humanitarian and commercial logistics. Pettit and Beresford (2009) conducted a literature review to identify the main critical success factors in humanitarian logistics. Natarajarathinam et al. (2009) developed a literature review on supply chain management (SCM) in times of crisis, demonstrating the disruptions suffered by supply chains due to disasters and other crisis situations, such as strikes, and the recovery processes implemented by the chain members. Overstreet et al. (2011) made a literature review to address humanitarian logistics, specifically in disasters whose onset is sudden. Kunz and Reiner (2012) developed a meta-analysis of the humanitarian logistics literature, identifying the need for further research about continuous aid operations, slow-onset disasters, man-made disasters, reconstruction phases and empirical research.

A series of systematic literature reviews in the area began in 2014, for example, Leiras et al. (2014) offered a broad classification of the humanitarian logistics literature, based on 228 papers. Abidi et al. (2014) developed a systematic review focused on performance measurement and management in humanitarian supply chains. Nurmala et al. (2017) carried out a systematic literature review to understand the state of the art of partnerships between humanitarian organizations and companies in the management of humanitarian logistics. Bealt and Mansouri (2018) decided to carry out a review focusing on community participation in humanitarian logistics activities, revealing that communities are able to form networks with a greater capacity to meet a wide range of disaster management needs, called Collaborative Aid Networks (CANs). More recently, Behl and Dutta (2019) developed a systematic literature review focusing on Humanitarian Supply Chain Management (HSCM), which was divided into ten parts: review-based research, classification of

HSC with respect to disaster phases, shift in trend from disaster management to HSCM, humanitarian logistics and its categories, resilience, information technology, mathematical models, theoretical underpinning, a case-study-based approach, and performance management of HSCM. Jabbour et al. (2019) carried out a systematic literature review about HSCM and HL with the aim of renewing the classification of the literature and identifying gaps for future research. With a focus on measuring performance in HO, HL and HSC, Banomyoung et al. (2019) conducted a review in which some bibliometric techniques for scientific mapping appeared, but it was rather restricted to the performance theme. Modgil et al. (2020) carried out a systematic literature review specifically focused on quality management applied to humanitarian operations and disaster relief management, composed of 61 articles published from 2009 to 2018. Recently, Fosso-Wamba (2020) used a bibliometric approach as the main review methodology to develop a performance analysis of the HSC literature. The latter author exposes the gap in bibliometric studies in the area under analysis through the following statement: “Still, unfortunately, there is a scarcity of bibliometric studies investigating and reporting the latest advances of the HSC” (p. 3). Furthermore, as we are in the era of big data and there is a constant increase in HSC documents, he proposes the use of a bibliometric approach to facilitate studies in the field. The bibliometric method has, in addition to the performance analysis approach (which was explored by Fosso-Wamba, 2020), the scientific mapping approach, which still needs to be explored in the area under study.

Although there are already several literature reviews in the area, we did not identify any paper that adopts the bibliometric mapping approach as the main methodology for displaying the intellectual structure of the HO research field. Bibliometric mapping is a quantitative method that allows visualization of scientific literature from bibliographic data, allowing identification of the intellectual structure of the research area through analysis of the interrelationships between articles (Argoubi et al., 2020). The intellectual structure of a field of knowledge is a structured representation of the knowledge produced, representing a set of attributes that can indicate a holistic understanding of the scientific domain, including its research traditions, disciplinary composition, topics covered and patterns of interrelations (Calabretta et al., 2011; Shafique, 2013). To present HO’s intellectual structure, bibliometric mapping was chosen, which is widely accepted in the scientific community (McCain, 1990; Borgman & Furner, 2002; Börner et al., 2003; Boyack et al., 2005). A bibliometric map can facilitate understanding of the contemporary state of knowledge, assist in the identification of new discoveries, and promote synthesis of knowledge (Small, 1999). According to Zupic and Cater (2015), the synthesis of science is one of the most important activities for advancement of a specific line of research. Due to its rigor and robustness, bibliometric mapping has been used by scholars in the management area (Zupic & Cater, 2015) to map the intellectual structure of its research fields, such as Strategic Management (Nerur et al., 2008), Operations Management (Pilkington & Meredith, 2009), and Innovation Research (Shafique, 2013). Thus, the objective of this article is to identify and understand the organization of the intellectual structure of the HO research field through bibliometric methods of scientific mapping, filling the identified research gap. Specifically, we address the following research questions:

- RQ1: How is the humanitarian operations literature structured and intellectually organized?
- RQ2: How is the recent or emerging literature on humanitarian operations intellectually structured? What are the trends in this study area?

- RQ3: What are the main conceptual building blocks for the literature on humanitarian operations?

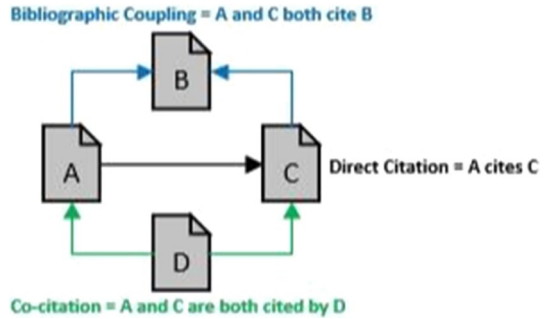
To answer RQ1, the bibliometric co-citation analysis technique was selected, as it allows identification of the most influential works in the research field, resulting in a map of the main works of the HO, separated into thematic clusters (Small, 1999; Zupic & Cater, 2015). Regarding RQ2, the bibliographic coupling technique was selected, because it has the ability to identify emerging works and "hot topics" of research (Boyack & Klavans, 2010; Small, 1999; Zupic & Cater, 2015), offering as a main result a relational map of emerging works, divided into thematic clusters. Finally, to answer RQ3, co-occurrence of keywords was used, which is a technique that aims to identify the most relevant keywords used in the works in the area analyzed (Zupic & Cater, 2015). The main result is a list of the most important keywords, which, due to their ability to synthesize the content, represent the conceptual building blocks of literature (Courtial et al., 1984).

Our research contributes both to the literature and to practice. Our contribution to the literature is threefold. First, we present a complete mapping of the intellectual structure of HO, providing: the identification of the main works classified into clusters; the identification of the emerging intellectual structure ("hot topics" for research); and the identification of the main conceptual building blocks in HO. Second, this research adds to previous studies that reviewed HO literature by adopting a quantitative perspective. Finally, we propose an avenue for future studies based on the findings of bibliometric mapping. Our research also contributes to the practice by identifying subthemes in each cluster, which can indicate trends for the selection of tools by managers who work with HO. The rest of the paper is organized as follows: Sect. 2 presents in detail the methodology used. Then, Sect. 3 shows details of the procedures applied, the results and interpretations of the mapping work. Section 4 presents a discussion on the dynamics of the intellectual structure and the contributions of this study, while Sect. 5 points out its limitations and provides suggestions for future research. Finally, Sect. 6 presents the conclusion.

2 Methodology

This work was based on bibliometric methods, which have two main uses: performance analysis and scientific mapping (Cobo et al., 2011; Zupic & Cater, 2015). While performance analysis seeks to evaluate the performance of publications in a given research area, scientific mapping aims to reveal the dynamics and structure of scientific fields. According to Zupic and Cater (2015), this information on structure and development is useful when the researcher's objective is to review a specific line of research. Therefore, this study carries out a scientific mapping of humanitarian operations, using some bibliometric techniques, to provide an overview of the organization and structure of such a research area. To construct the maps of the HO literature, bibliometric techniques of co-citation, bibliographic coupling and co-occurrence of keywords were used. Co-citation analysis is understood as the frequency with which two units are cited together, indicating similarity between them (Small, 1973). Bibliographic coupling uses the number of references shared by two articles as a measure of similarity between them, that is, the more the bibliographies of two articles overlap, the stronger their connection (Kessler, 1963). Figure 1 shows how citations relate to documents in these bibliometric techniques.

Fig. 1 Bibliometric techniques.
Source Adapted from Persson
et al. (2009)



Co-occurrence, on the other hand, finds word connections when they co-occur, enabling use of the most important words or keywords in the documents to study the conceptual structure of a research field (Callon et al., 1983). The idea behind the technique is that, when words frequently co-occur in documents, it means that the concepts represented by these words are closely related (Zupic & Cater, 2015). For each of these bibliometric techniques, the workflow recommended by Zupic and Cater (2015) was used to carry out scientific mapping studies in the area of administration and organizational studies, consisting of five stages, as shown in Fig. 2.

The first step is to conceive the investigation, defining the research question and choosing the appropriate bibliometric method to answer it. In the second stage, there occurs compilation of the bibliometric data, with selection of the database, sorting and export of the data set of this database. The third stage consists of analysis with application of some bibliometric software to analyze the data set (statistical software can also be used together to identify subgroups of documents that represent research specialties). The fourth step is visualization, which occurs by choosing the appropriate method and software to generate the maps and graphs. Finally, the fifth step consists of interpreting the results. Considering that, the chosen method is intrinsic to the development of the study and presentation of the results, this section is limited to the presentation and foundation of the scientific methodology adopted. In the next section, every decision taken by the authors is detailed at each stage of the methodological workflow adopted.

3 Mapping process: procedures and results

3.1 Research design

This study carries out a complete scientific mapping of the humanitarian operations area, including, for this purpose, studies on humanitarian operations management, humanitarian supply chain management and humanitarian logistics. The unionist perspective was adopted for this study, based on the research by Day et al. (2012), considering humanitarian logistics as

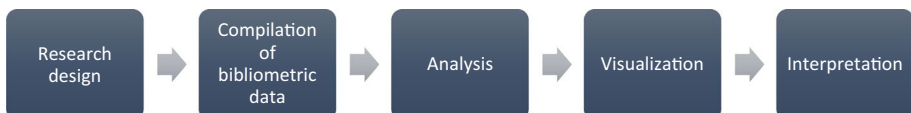


Fig. 2 Scientific mapping workflow. Source Adapted from Zupic and Cater (2015)

a subset of humanitarian supply chain management, which in turn is a subset of humanitarian operations management. Following the methodological model adopted, three guiding questions for the research were defined (RQ1, RQ2 and RQ3), as presented in the introduction of the article. There are bibliometric methods that are best suited to answer each of the questions, according to their type, as will be discussed below. To answer RQ1, the bibliometric citation analysis technique was chosen because it is the most suitable for identifying the general intellectual structure of research fields (Small, 1999; Zupic & Cater, 2015). The expected result of the co-citation analysis of the HO literature is a map with the main works in the area organized in clusters (thematic groups), each corresponding to a knowledge domain that reflects the intellectual structure of the field. The bibliographic coupling analysis technique was selected to answer RQ2, because it is the most suitable for identifying hot research topics and emerging works (Boyack & Klavans, 2010; Small, 1999; Zupic & Cater, 2015), which correspond to the recent intellectual structure of the research field. The expected result of the bibliographic coupling analysis is a map with articles emerging from the HO literature divided into clusters, each corresponding to a knowledge domain that represents the research trends in the area. In relation to RQ3, according to Zupic and Cater (2015), the technique of keyword co-occurrence is the most suitable to find the main conceptual building blocks of a literature. The expected result is a map with the main keywords of the articles in the database, allowing their association with concepts.

3.2 Compilation of bibliometric data

The database selected for this work was the Web of Science (WoS)—Core Collection, as it is considered one of the most important bibliographic bases for scientific publications and the most used in bibliometric studies in the management area (Cobo et al., 2011; Zupic & Cater, 2015). It is important to note that additional databases were not used because, for the type of study in question, in which the main raw material is bibliographic data (Thelwall, 2008), there are no incremental gains that justify working with several databases. This which would not happen if it were a traditional literature review, in which the raw material is the articles retrieved by the database search tool. For the type of study proposed, it is not uncommon to use only one database, as in the articles by Mishra et al. (2018) and Ferreira and Santos (2018), in which only the SCOPUS (Elsevier) database was used to perform bibliometric mapping, as well as in the works of Fosso-Wamba (2020) and Argoubi et al. (2020), which used only Web of Science (WoS) to conduct a bibliometric study. The keywords used for the advanced search in the WoS database, with the respective Boolean operators, can be seen in Table 1.

The choice of such keywords to search for the articles is justified, as they are the most used in the most well-known literature review works in the area (Abidi et al., 2014; Altay & Green, 2006; Banomyoung et al., 2019; Kovács & Spens, 2007; Kunz & Reiner, 2012; Leiras et al., 2014; Overstreet et al., 2011; Pettit & Beresford, 2009). The exception is the term “humanitarian network”, which was included by the authors of this paper because they perceived that there is a tendency for its use by many authors in the field under analysis. The period selected in the search ranged from 1945 to December 2020. The first search was restricted to the “topic” field (title, abstract and keywords) and “English” language, returning 2188 documents. Then, the document type filters, “articles” and “reviews”, were applied to the search, returning 1700 documents.

The 1700 documents were submitted to the reading of their titles and abstracts, with the aim of excluding articles that did not belong to the knowledge domain and matter

Table 1 Keywords and syntax used in Web of Science

Keywords	Search syntax (search performed on 10 February, 2021 in Web of Science)
Disaster operation	TS= ("humanitarian operation*" OR "humanitarian logistic*" OR "humanitarian supply chain*" OR "humanitarian supply chain management" OR "disaster operation*" OR ("disaster relief" AND humanitarian) OR (humanitarian AND network*) OR (humanitarian AND "relief chain*")) (ENGLISH) AND (ARTICLE OR REVIEW)
Disaster operations	
Disaster relief	
Humanitarian	
Humanitarian logistics	
Humanitarian supply Chain	
Humanitarian supply Chain management	
Humanitarian supply chains	
Humanitarian operation	
Humanitarian operations	
Network	
Networks	
Relief chain	
Relief chains	

under analysis. This led to the exclusion of 448 articles. It is important to note that, in this screening stage, the contexts of the articles were analyzed to identify whether they really addressed the issues of humanitarian operations. In several cases, although the articles used some disaster or humanitarian aid issue, they addressed other areas of knowledge, resulting in their exclusion. Thus, the final database for the development of this study, totaling 1252 articles (which cover the total time cut from 1945 to December 2020), was used in the analysis of co-citation and keywords co-occurrence to respond to RQ1 and RQ3, respectively. Specifically, for the use of bibliographic coupling (to answer RQ2), as the technique aims to identify emerging trends in the field and requires the use of only the most recent articles (Boyack & Klavans, 2010; Jarneving, 2007; Small, 1999), only articles published between 2016 and 2020 were considered, resulting in 864, which represents more than half of the total. As recommended by Zupic and Cater (2015), a maximum time horizon of five years must be adopted for the correct use of bibliographic coupling. As the last year of publication to appear in the selection of the co-citation analysis was 2015, we considered 2016 as the starting year for the analysis of bibliographic coupling, which, until December 2020, totals 5 years, which is within the limit mentioned in the literature. Figure 3 illustrates the database compilation process.

3.3 Analysis, visualization and interpretation

For the construction of the mapping, the visualization of similarities (VOS), developed by Van Eck and Waltman (2007a), was used, which is a unified approach to mapping and clustering bibliometric data, with techniques derived from the same underlying principle (Waltman et al. 2010). The purpose of the VOS technique is to locate elements in such a way that the distance between them represents their similarities (or affinities) as accurately as possible. The VOS technique requires a s_{ij} similarity measure ($s_{ij} \geq 0$) as an input for each pair of elements i and j . Such a measure of similarity is calculated using the strength

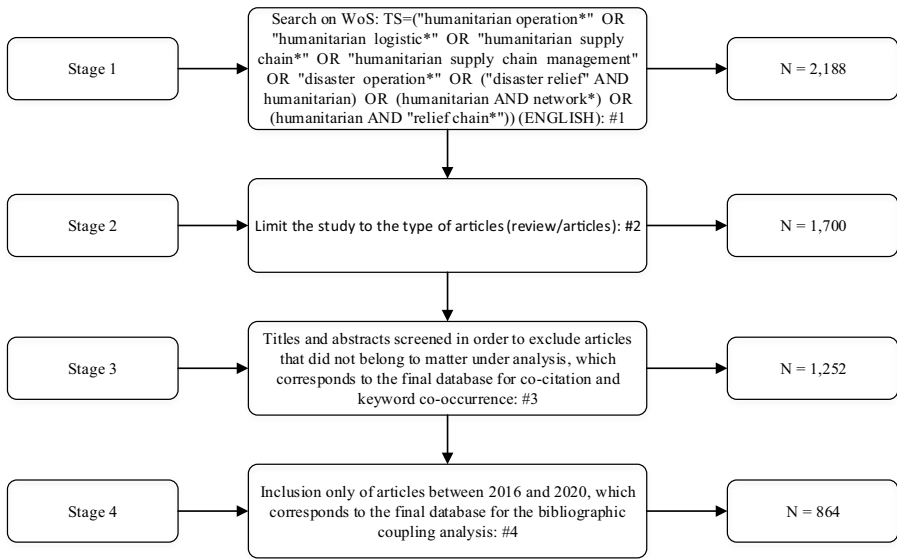


Fig. 3 Database compilation process

of the association between the elements, as can be seen in Eq. (1) (Van Eck & Waltman, 2007b; Van Eck et al. 2006).

$$S_{ij} = \frac{C_{ij}}{C_i C_j} \tag{1}$$

In the equation, S_{ij} is the strength of the association between the elements i and j , and C_{ij} is the number of co-occurrences of i and j . The strength of the elements i and j is proportional to the ratio between the observed number of co-occurrences of i and j and the expected number of their co-occurrences, considering that these co-occurrences are statistically independent (Van Eck & Waltman, 2009). To determine the location of the elements on a map, the VOS technique uses Eqs. (2) and (3):

$$V(x_1, \dots, x_n) = \sum_{i < j} s_{ij} ||x_i - x_j||^2 \tag{2}$$

$$\frac{2}{n(n-1)} \sum_{i < j} ||x_i - x_j|| = 1 \tag{3}$$

Thus, the VOS technique minimizes the weighted sum of squared distances between all pairs of elements. The square of the distance between a pair of elements is weighted by the measure of similarity between them, according to Eq. (2). In order to avoid trivial solutions, in which all elements occupy the same location, a restriction was imposed on Eq. (3), in which the average distance between two points must be equal to one (Van Eck et al., 2010). The bibliometric software chosen for the analysis stage was VOSviewer, version 1.6.8.0. The use of this software allows a complete analysis based on the techniques of scientific mapping, through the formation of maps, which are presented in the form of

networks that contain "nodes" (elements) and "links" between them, such as links of bibliographic coupling between publications (Van Eck & Waltman, 2010, 2014). Each link of the networks generated has a "strength", represented by a positive numerical value, which may, for example, indicate the number of cited references that two publications have in common in the case of bibliographic couplings (Van Eck & Waltman, 2010). The proximity between elements on the map is also an indication of strength, that is, the closer the two elements are, the stronger the connection between them (Van Eck et al. 2010). The selected software algorithm also divides network elements into clusters (Waltman et al., 2010). In order to determine the importance of the elements of each network, the following elements were considered: the "total link strength" (TLS) attribute, which indicates the total strength of the links of an element with other elements; or the "occurrences" attribute, which indicates the number of repetitions of the element.

3.3.1 Co-citation analysis

To answer the first research question, the database extracted from WoS was loaded into the VOSviewer software, in which the type of analysis, "co-citation", the unit of analysis, "cited references" and the counting method, "full counting" were selected. As the expected result of the analysis is the formation of a map/network, the number of elements that will appear in its composition is fundamental, as it will determine its intelligibility, that is, a map that contains elements in excess will not be intelligible and will not support visualization through a figure in a scientific work. Thus, after carrying out several tests on the software, it was concluded that, in order to allow a good visualization of the map generated, there was a need to use as a parameter the minimum quantity of 64 citations of a reference (which also increases the significance of the documents), as it results in a mapped network of 43 elements, as shown in Fig. 4, which is a reasonable size to view all the elements on a page. To increase the reliability of the result, the Bibexcel software (Persson et al., 2009) was also used to set up the co-citation network, which, when viewed on the VOSviewer, obtained the same result.

The network of co-citation analysis (Fig. 4) represents the basic intellectual structure of the HO area. It is composed of the most HO important papers, which are the conceptual foundations that serve as a basis for this research field. In this map, it is also possible to notice that the circle and the representation label of each document are proportional to

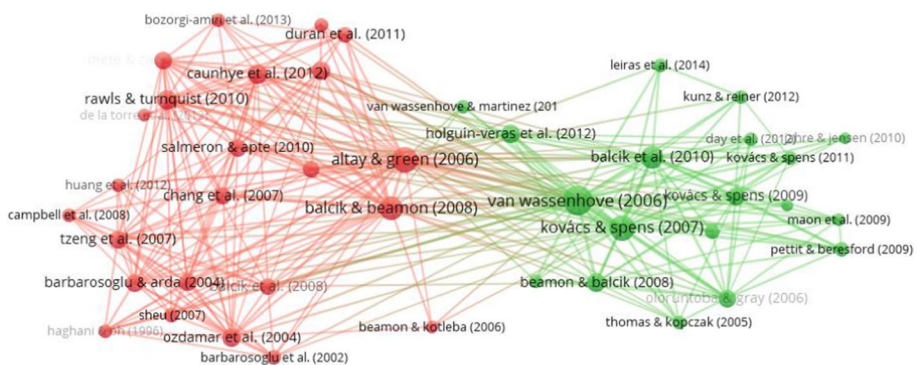


Fig. 4 Co-citation analysis of the humanitarian operations literature

the importance of the work (Van Eck & Waltman, 2010). As the co-citation technique retrieves the references cited by the authors of the articles from the database collected, the network represents the main articles in the area under study (Zupic & Cater, 2015). The full version of these articles was downloaded on the electronic platforms of each journal responsible for the publication.

A content analysis, which has been used in several theoretical review articles (Brandenburg & Rebs, 2015; Hazen et al., 2012; Kache & Seuring, 2014; Queiroz et al., 2020; Seuring & Gold, 2012), was carried out by reading the full content of articles. The content analysis was based on the technique of noting patterns and themes (Miles et al., 2014), in conjunction with category selection (Mayring, 2014). Based on such content analysis techniques, structural dimensions and analytical categories were defined for extraction of data from articles in an inductive way, that is, emerging from the analysis of the paper. In addition to this categorization, the most frequent keywords were identified in each set of articles that make up the cluster. Finally, these patterns of each cluster were summarized in a main theme that defines it, which, in this study, we call the suggested label for the cluster. The structural dimensions chosen for the classification of articles were “Main Topics/Themes” (containing several categories according to the cluster) and “Theoretical lens/Main concept/Model”. Table 2 presents the summary of the content analysis of the articles in the green cluster, and Table 4, the same in relation to the red cluster.

The green cluster contains 19 articles that address issues of Supply Chain Management (SCM) in the context of humanitarian operations. These papers are focused on theoretical approaches and clarification of concepts. Initially, SCM concepts and practices were applied in the context of humanitarian aid due to the need to increase the efficiency of its operations. However, the unique characteristics caused by contextual factors of chaotic disaster environments began to stand out as a justification for different forms of humanitarian supply chain management.

It is important to note that the field under analysis has become better known under the umbrella nomenclature, Humanitarian Logistics (HL), although this is a subset of Humanitarian Supply Chain Management (HSCM), which addresses broader issues in addition to the logistics function (Day et al., 2012). Thus, in the content analysis, the following themes that emerged as a pattern were identified: SCM Practices/Strategies, Logistics management, Coordination, Partnerships, Disaster management lifecycle, Performance measurement and HSC Design. The discussion most frequently found in the green cluster is the cross-learning between Commercial and Humanitarian SCM or Commercial and Humanitarian Logistics. The common trait of this cross-learning is that the applications of the business environment have a background that can be used and adapted to the humanitarian field, and, on the other hand, the body of knowledge of humanitarian aid could indicate to the business environment ways of acting in chaotic and high-risk environments. The only consolidated theory that appeared in the green cluster was the Stakeholder Theory, used by Kovács and Spens (2009). The other articles in the green cluster presented main concepts that can be classified as part of the discussion of the SCM phenomenon.

Regarding the most frequent keywords in articles in the green cluster, there was a greater appeal for the umbrella nomenclature, “humanitarian logistics” (7 repetitions). The term “disasters” also stood out (6 repetitions), demonstrating the intention of the authors to identify the research context. The keyword, “Supply Chain Management” appeared with 5 repetitions, and, closing the list, the term, “aid agencies” (4 repetitions) appeared, which

Table 2 Co-citation analysis in the humanitarian operations literature: Green Cluster

TLS	Cited references	Main topics/themes					Performance measurement	HSC design	Theoretical lens/main concept/model	Most frequent keywords	Label
		SCM practices/strategies	Logistics management	Coordination	Partnerships	Disaster management lifecycle					
2,406	Van Wassenhove (2006)	X	X	X	X	X	X	SCM and HSCM	Humanitarian logistics (7); Disasters (6); Supply chain management (5); Aid agencies (4); Humanitarian supply chain (3)	Humanitarian Supply Chain Management (HSCM)	
1,831	Kovács and Spens (2007)	X	X			X		Business/humanitarian logistics			
1,547	Balcik et al. (2010)	X	X	X		X		SCM coordination			
1,047	Beamon and Balcik (2008)	X	X	X		X		SCM performance			
1,044	Holguín-Veras et al. (2012)	X	X			X		Deprivation costs			
1,008	Oloruntimehin and Gray (2006)	X					X	Agile supply chain			

Table 2 (continued)

TLS	Cited references	Main topics/themes				Disaster management lifecycle	Performance measurement	HSC design	Theoretical lens/main concept/model	Most frequent keywords	Label
		SCM practices/strategies	Logistics management	Coordination	Partnerships						
1,007	Kovács and Spens (2009)		X	X				Stakeholder theory			
704	Pettit and Beresford (2009)	X	X					Critical success factors			
680	Tomasini and Van Wassenhove (2009a)	X			X			Public private partnerships			
626	Leiras et al. (2014)		X			X		Humanitarian logistics			
621	Kunz and Reiner (2012)		X			X		Situational factors			
606	Day et al. (2012)	X	X					SCM and HSCM			
606	Kovács and Spens (2011)		X					Gap analysis			
591	Van Wassenhove and Pedraza Martinez (2012)	X	X			X		SCM			

Table 2 (continued)

TLS	Cited references	Main topics/themes					Performance measurement	Theoretical lens/main concept/model	Most frequent keywords	Label
		SCM practices/strategies	Logistics management	Coordination	Partnerships	Disaster management lifecycle				
581	Thomas and Kopczak (2005)	X	X				X	Humanitarian logistics		
580	Tomasini and Van Wassenhove (2009b)	X	X	X	X		X	SCM and HSCM		
546	Maon et al. (2009)	X	X	X	X			Corporate social responsibility		
479	Jahre and Jensen (2010)	X	X					Cluster analysis		
466	Tatham and Kovács (2010)	X	X		X			Swift trust		

was the most researched humanitarian aid stakeholder, and “Humanitarian Supply Chain” (3 repetitions), identifying the specific supply chains for humanitarian aid. In view of the evidence found in the content analysis of the selected articles, it is understood that the nomenclature that best summarized and identified the green cluster was “Humanitarian Supply Chain Management”, the articles being predominantly conceptual.

The most important articles in this cluster, which have a more centralized position and more links, were Van Wassenhove (2006) and Kovács and Spens (2007), with total link strengths calculated by the software of 2406 and 1831, respectively. It is important to highlight that the co-citation analysis identified the most important publications in the HO field. Therefore, these articles are two of the most prominent works in the area. The sources of the works are also an important indicator to identify the style of publications in the cluster. The most significant sources in the green cluster were those presented in Table 3, confirming the predominance of the theme of SCM and logistics management, with the “International Journal of Physical Distribution & Logistics Management” presenting greater significance with 26% of the articles of the green cluster.

As can be seen in Table 3, most of the green cluster sources are renowned international journals. However, it is important to highlight the existence of two exceptions. The INSEAD Business Press Series, which refers to the source of the academic book, “Humanitarian Logistics” (Tomasini & Van Wassenhove, 2009b), and the Fritz Institute, which refers to the source of the publication, “From logistics to supply chain management: The path forward in the humanitarian sector” (Thomas & Kopczak, 2005), which was a highly cited work in the seminal articles of HO. It is important to remember that, for this paper, only academic articles were selected in the database, but, as the co-citation technique uses the works cited for analysis (Cobo et al., 2011; Small, 1999; Zupic & Cater, 2015), the result was not limited to the articles that were selected, but to the works that the main authors in the area consider important. This is another advantage of using the co-citation technique, in addition to being an indication of its correct application.

With an Operational Research (OR) approach, the red cluster presents 24 works aimed at solving logistical problems to optimize physical distribution in humanitarian

Table 3 Green cluster sources

Sources	Count	Percentage
International Journal of Physical Distribution & Logistics Management	5	26
International Journal of Production Economics	2	11
International Transactions in Operational Research	2	11
Journal of Humanitarian Logistics and Supply Chain Management	2	11
Supply Chain Management: An International Journal	2	11
Fritz Institute (publication)	1	5
INSEAD Business Press Series (textbook)	1	5
International Journal of Public Sector Management	1	5
Journal of Operations Management	1	5
Journal of Supply Chain Management	1	5
Journal of the Operational Research Society	1	5
Total	19	100

operations. The articles in this cluster make extensive use of mathematical modeling with computational application. Through content analysis (Mayring, 2014; Miles et al., 2014), the main topics addressed by the articles in the red cluster were also identified, as detailed in Table 4, these being categorized into: Disaster Operations Management (DOM), Network flow and Vehicle routing, Facility location, Inventory management, Pre-positioning, Last-Mile distribution, Evacuation and Relief-demand management. Most of the articles deal with problems related to distribution logistics of humanitarian materials in disaster-affected places. It was decided to expand the categories mentioned by Duran et al. (2011) and adopted by Leiras et al. (2014)—installation location, inventory management and network flows—to better explore the themes covered in the red cluster.

All the articles in this cluster used mathematical models addressed in the OR/MS literature to solve logistical problems. Recurring characteristics observed in these models were the use of multiple objectives, more than one resolution stage and stochastic methods for solving complex problems with various restrictions. The most frequent keywords in the red cluster were (with the respective repetition count in parentheses): Humanitarian logistics (5), Vehicle routing (5), Pre-positioning (3), Optimization (2) and Multi-objective optimization (2). Connecting the content analysis (Miles et al., 2014) with the most frequent keywords, it is evident that the main objective of the articles in this cluster was to optimize the physical distribution of humanitarian aid items. Therefore, it received the nomenclature, “Distribution optimization in humanitarian logistics”.

On the map, it is possible to verify that the most prominent articles are Altay and Green (2006) and Balcik and Beamon (2008), with total link strengths of 1942 and 1646, respectively. The most significant journals in the red cluster also indicate a predominance of modeling and OR/MS, as shown in Table 5, with the "European Journal of Operational Research" (21% of articles) and "Transportation Research Part E" (17% of articles).

According to Miles et al. (2014), one of the tactics to generate meaning in content analysis is the creation of metaphors, as they help to connect findings to theory. Considering the characteristics of the cognitive structure of HO literature presented in the co-citation analysis (which responds to RQ1), we proposed, through Fig. 5, the “Humanitarian Operations knowledge building” framework (based on a metaphor). This tactic is used in operations management research, examples of which are the “Sand cone” by Ferdows and De Meyer (1990), and the “House of supply chain agility” by Charles et al. (2010). The proposed framework has the shape of a building. The top or roof is the HO knowledge field, which is supported by two main pillars: Humanitarian Supply Chain Management (HSCM) and Distribution Optimization in Humanitarian Logistics (DOHL). Such pillars correspond to the two clusters identified in the co-citation analysis. Considering the content of the articles in the clusters, each pillar is based on the predominant methodological approach (which is the foundation). For the methodological approach, the following classification was considered (Leiras et al., 2014; Natarajarathinam et al., 2009): conceptual (which discusses new concepts), analytical (simulation or mathematical modeling), empirical (includes data collection and evaluation and observations), or applied (case studies, opinions and interviews). Thus, the HSCM pillar is based, predominantly, on a conceptual methodological approach, within the knowledge domain of Operations Management (OM), whereas the DOHL pillar has as its foundation a predominantly analytical

Table 4 Co-citation analysis in the humanitarian operations literature: Red Cluster

TLS	Cited references	Main topics/themes						Theoretical lens/main concept/model	Most frequent keywords	Label
		DOM	Network flow and vehicle routing	Facility location	Inventory management	Pre-positioning	Last-Mile distribution			
1942	Altay and Green (2006)	X							Humanitarian logistics (5); Vehicle routing (5); Pre-positioning (3); Optimization (2); Multi-objective optimization (2)	Distribution optimization in humanitarian logistics
1646	Balcik and Beamon (2008)		X	X		X			maximal covering location problem (MCLP)/mixed integer programming (MIP)	

Table 4 (continued)

TLS	Cited refer-ences	Main topics/themes						Theoretical lens/main concept/model	Most frequent keywords	Label
		DOM	Network flow and vehicle routing	Facility location	Inventory management	Pre-positioning	Last-Mile distribution			
1166	Rawls and Turnquist (2010)		X	X	X	X		Two-stage stochastic mixed integer program (SMIP) and heuristic algorithm—Lagrangian L-shaped method (LLSM)		
1140	Caunhye et al. (2012)	X	X	X	X	X		Optimization models in emergency logistics		
1072	Ozdamar et al. (2004)		X					Linear and integer multi-period multi-commodity network flows with Lagrangean relaxation		

Table 4 (continued)

TLS	Cited refer-ences	Main topics/themes							Theoretical lens/main concept/model	Most frequent keywords	Label
		DOM	Network flow and vehicle routing	Facility location	Inventory management	Pre-positioning	Last-Mile distribution	Evacuation			
1065	Galindo and Batta (2013)	X								OR/MS in DOM	
984	Mete and Zabinsky (2010)		X	X	X					Two-stage stochastic programming (SP) model and mixed-integer programming (MIP) model	
967	Barbarosoglu and Arda (2004)		X							Two-stage stochastic linear programming/multi-modal network flow problem	
929	Yi and Ozdamar (2007)		X	X				X		Mixed integer multi-commodity network flow model	

Table 4 (continued)

TLS	Cited refer-ences	Main topics/themes							Theoretical lens/main concept/model	Most frequent keywords	Label
		DOM	Network flow and vehicle routing	Facility location	Inventory management	Pre-positioning	Last-Mile distribution	Evacuation			
922	Tzeng et al. (2007)		X						X	Multi-objective programming method	
914	Salmeron and Apte (2010)			X		X			X	Two-stage stochastic optimization model/Pre-positioning Optimization (PO) Model	
886	Balcik et al. (2008)		X		X					Mixed integer programming model/Intelligent Transportation Systems (ITS)	

Table 4 (continued)

TLS	Cited refer-ences	Main topics/themes							Theoretical lens/main concept/model	Most frequent keywords	Label
		DOM	Network flow and vehicle routing	Facility location	Inventory management	Pre-positioning	Last-Mile distribution	Evacuation			
825	Chang et al. (2007)		X	X					X	Multi-echelon location models under uncertainty and sample average approximation scheme	
822	Holguín-Veras et al. (2013)		X							Optimization model with social costs and welfare economic concepts	
761	Duran et al. (2011)				X		X			Mixed-integer programming (MIP) inventory-location model	

Table 4 (continued)

TLS	Cited refer-ences	Main topics/themes							Theoretical lens/main concept/model	Most frequent keywords	Label
		DOM	Network flow and vehicle routing	Facility location	Inventory management	Pre-positioning	Last-Mile distribution	Evacuation			
699	Sheu (2007)		X							Hybrid fuzzy clustering-optimization/ Multi-objective optimization	
690	Barbarosoglu et al. (2002)		X							Hierarchical multi-criteria decision making	
630	Haghani and Oh (1996)		X							Multi-commodity multi-modal network flow problem/mixed integer linear programming model	

Table 4 (continued)

TLS	Cited refer-ences	Main topics/themes							Theoretical lens/main concept/model	Most frequent keywords	Label
		DOM	Network flow and vehicle routing	Facility location	Inventory management	Pre-positioning	Last-Mile distribution	Evacuation			
628	Campbell et al. (2008)		X							Two alternative objective functions for the traveling salesman problem (TSP) and the vehicle routing problem (VRP)	
625	Ozdamar and Ertem (2015)		X							Modeling approaches and Information systems	
624	Huang et al. (2012)		X	X				X		Last-mile delivery problem (LMDP) with alternative objectives/Integer programming model	

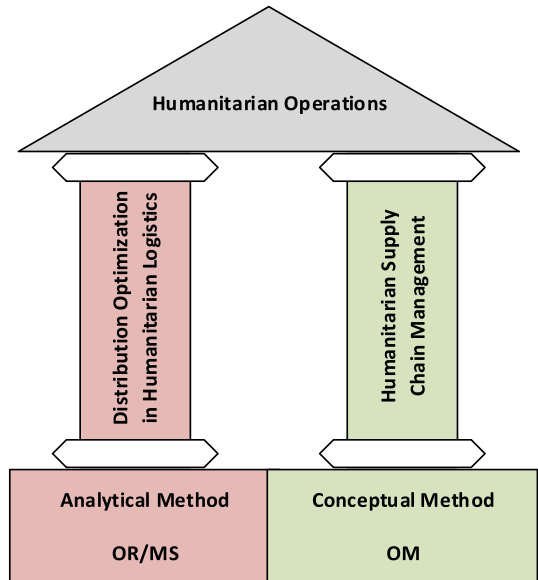
Table 4 (continued)

TLS	Cited refer-ences	Main topics/themes							Theoretical lens/main concept/model	Most frequent keywords	Label
		DOM	Network flow and vehicle routing	Facility location	Inventory management	Pre-positioning	Last-Mile distribution	Evacuation			
596	Bozorgi-Amiri et al. (2013)			X		X				Multi-objective robust stochastic programming approach	
532	De la Torre et al. (2012)		X							OR/MS models	
509	Beamon and Kotleba (2006)				X					Stochastic inventory control model	

Table 5 Red cluster sources

Sources	Count	Percentage
European Journal of Operational Research	5	21
Transportation Research Part E	4	17
International Journal of Logistics: Research and Applications	2	8
Socio-Economic Planning Sciences	2	8
Annals of Operations Research	1	4
Interfaces	1	4
International Journal of Production Economics	1	4
Journal of Intelligent Transportation Systems	1	4
Journal of Operations Management	1	4
Journal of the Operational Research Society	1	4
OR Spectrum	1	4
Production and Operations Management	1	4
Transportation Research Part A	1	4
Transportation Research Part B	1	4
Transportation Science	1	4
Total	24	100

Fig. 5 Humanitarian Operations knowledge building



approach, based on the knowledge domain of Operational Research/Management Science (OR/MS).

3.3.2 Bibliographic coupling analysis

To answer the second research question, the database of the set of articles published between 2016 and 2020 was loaded into the VOSviewer software, selecting "bibliographic coupling" as the type of analysis, and marking the "document" type as the unit of analysis. After carrying out some tests in the software, it was decided that, to allow an intelligible visualization of the map, there was a need to use as a parameter the minimum quantity of 31 citations of a document, resulting in a mapped network of 43 components. The map showing emerging articles with research trends in the area (Zupic & Cater, 2015), can be seen in Fig. 6, representing a network with three clusters, in which the closer the center of the cluster, the bigger the node (element) and more important the item.

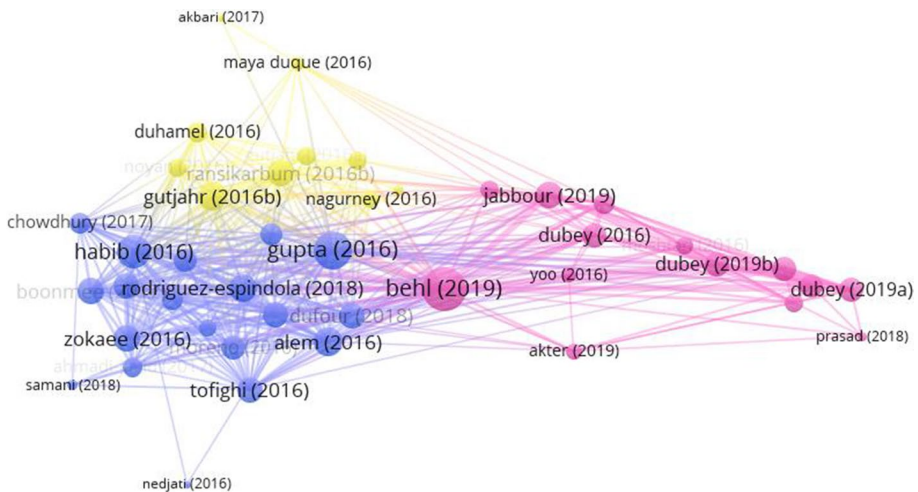


Fig. 6 Bibliographic coupling analysis of the humanitarian operations literature. Note: the labels automatically generated by the software correspond to the following references: ahmadi-javid 2017 (Ahmadi-Javid et al., 2017); akbari 2017 (Akbari & Salman, 2017); akter 2019 (Akter & Fosso-Wamba, 2019); alem 2016 (Alem et al., 2016); altay 2018 (Altay et al., 2018); banomyong 2019 (Banomyoung et al., 2019); bealt 2016 (Bealt et al., 2016); behl 2019 (Behl & Dutta, 2019); boonmee 2017 (Boonmee et al., 2017); burkart 2017 (Burkart et al., 2017); cavdur 2016 (Cavdur et al., 2016); charles 2016 (Charles et al., 2016); chowdhury 2017 (Chowdhury et al., 2017); dubey 2016 (Dubey & Gunasekaran, 2016); dubey 2018 (Dubey et al., 2018); dubey 2019a (Dubey et al., 2019b); dubey 2019b ((Dubey et al., 2019c); dufour 2018 (Dufour et al., 2018); duhamel 2016 (Duhamel et al., 2016); fahimnia 2017 (Fahimnia et al., 2017); gupta 2016 (Gupta et al., 2016); gutjahr 2016a (Gutjahr & Nolz, 2016); gutjahr 2016b (Gutjahr & Dzibur, 2016); habib 2016 (Habib et al., 2016); jabbour 2019 (Jabbour et al., 2019); manopiniwes 2017 (Manopiniwes & Irohara, 2017); maya duque 2016 (Maya Duque et al., 2016); moreno 2016 (Moreno et al., 2016); moshtari 2016 (Moshtari, 2016); nagurney 2016 (Nagurney et al., 2016); nedjati 2016 (Nedjati et al., 2016); noyan 2016 (Noyan et al., 2016); papadopoulos 2017 (Papadopoulos et al., 2017); perez-rodriguez 2016 (Pérez-Rodríguez & Holguín-Veras, 2016); pradhananga 2016 (Pradhananga et al., 2016); prasad 2018 (Prasad et al., 2018); ransikarbum 2016a (Ransikarbum & Mason, 2016b); ransikarbum 2016b (Ransikarbum & Mason, 2016a); rodriguez-espindola 2018 (Rodríguez-Espindola et al., 2018); samani 2018 (Samani et al., 2018); tofighi 2016 (Tofighi et al., 2016); yoo 2016 (Yoo et al., 2016); zokae 2016 (Zokae et al., 2016)

The importance of the element is also proportional to the size and visibility of the letters that identify it, as assigned by the adopted software algorithm, so less important elements may have the caption suppressed in the visualization (Van Eck & Waltman, 2010). The 43 documents resulting from the bibliographic coupling analysis are all scientific articles, and were already part of the records of the selected database used. Most articles that make up each cluster have an OR/MS approach, and only the Purple Cluster contains all the articles with other approaches and methods, as can be seen in the graph in Fig. 7, in which the size of the bubbles corresponds proportionally to the total number of citations for each cluster.

To obtain the complete texts, the download was made directly on the electronic platforms of each journal responsible for the publication. Thus, the articles were read in full to allow content analysis to be carried out (Mayring, 2014; Miles et al., 2014) and to enable an understanding of the emerging intellectual structure in the field of humanitarian operations. In this way, the same structural dimensions defined for the analysis of the co-citation technique were used. Following the pattern of the previous analysis, the most frequent keywords were identified in each set of articles that made up each cluster. At the conclusion of the analysis, all of these patterns for each cluster were summarized under their suggested label. Tables 6, 7 and 8 respectively show the composition of the yellow, purple and blue clusters (formed by the VOSviewer software), and the main concepts and topics covered in the articles that compose each one.

The yellow cluster contains articles that aimed at improving mathematical modeling for application in chaotic disaster environments, including multiple objectives and criteria. There was an emphasis on optimization models with multi-objectives (Burkart et al., 2017; Duhamel et al., 2016; Gutjahr & Nolz, 2016; Ransikarbum & Mason, 2016a, 2016b) with a focus on restoring networks after disruptions due to impact of disasters (Ransikarbum & Mason, 2016a, 2016b; Maya Duque et al., 2016; Akbari & Salman, 2017). The articles in

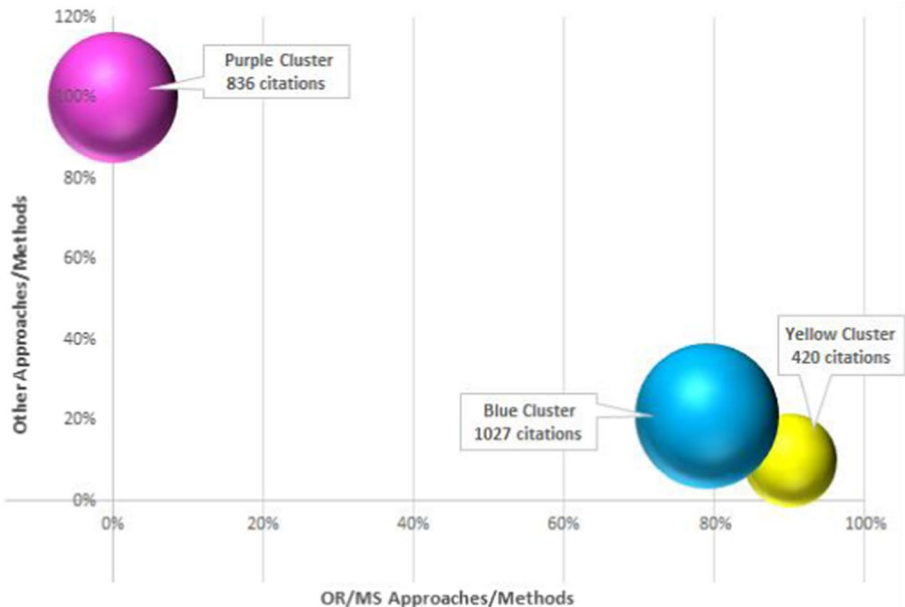


Fig. 7 Research approach to bibliographic coupling analysis clusters

Table 6 Bibliographic coupling analysis in the humanitarian operations literature: Yellow Cluster

Cited references	Main topics/themes				Theoretical lens/ main concept/ model	Most frequent keywords	Label
	Network flow and Vehicle routing	Facility location	Inventory manage- ment	Network/supply chain disruption and restoration			
257 Gujtahr and Nolz (2016)	X	X	X		Multicriteria deci- sion making	Humanitarian logistics (6); Dis- aster relief (3); Multiple objec- tive optimization (2); Equity (2); Optimization (2)	Network flow restoration opti- mization
215 Ransikarbum and Mason (2016a)	X			X	Goal program- ming-based multiple-objec- tive integrated response and recovery model		
116 Duhamel et al. (2016)	X	X			Multi-period location-alloca- tion problem/ Resilience system models		
110 Gujtahr and Dzibur (2016)		X	X		Multi-objective optimization/ Bi- level program- ming		
105 Noyan et al. (2016)	X			X	Stochastic last mile relief network design problem (SLMRND)/ Two-stage sto- chastic program- ming model		

Table 6 (continued)

Cited references	Main topics/themes				Theoretical lens/ main concept/ model	Most frequent keywords	Label
	Network flow and Vehicle routing	Facility location	Inventory manage- ment	Network/supply chain disruption and restoration			
104 Ransikarbum and Mason (2016b)	X			X	X	Multiple-objective integrated net- work optimiza- tion model	
96 Nagurney et al. (2016)	X					Generalized Nash Equilibrium network model/ Game theory problem	
65 Maya Duque et al. (2016)	X			X		Dynamic program- ming (DP) algorithm/iter- ated greedy-rand- omized construc- tive procedure/ Network Repair Crew Schedul- ing and Routing Problem	
35 Burkart et al. (2017)	X		X			Multi-objective combinatorial optimization/ Choice-based view	

Table 6 (continued)

Cited references	Main topics/themes			Theoretical lens/ main concept/ model	Most frequent keywords	Label
	Network flow and Vehicle routing	Facility location	Inventory manage- ment			
17 Akbari and Salman (2017)	X				X	Mixed Integer Pro- gramming (MIP)/ Multi-vehicle Synchronized Arc Routing Problem to Restore Network Connectivity

Table 7 Bibliographic coupling analysis in the humanitarian operations literature: Purple Cluster

TLS	Cited references	Main topics/themes				Theoretical lenses/ main concept/ model	Most frequent keywords	Label
		HSCM	Performance measurement	HSC design	Emergent technology—big data and social media			
573	Behl and Dutta (2019)	X	X	X	X	Humanitarian supply chain management	Big Data (5); Humanitarian supply chain (5); Humanitarian logistics (3); Humanitarian operations (3); Resilience (2); Collaboration (2); Swift trust (2)	Relationship management and Big Data applications in HSC
217	Jabbour et al. (2019)	X				Humanitarian logistics and supply chain management (HLSCM)		

Table 7 (continued)

TLS	Cited refer-ences	Main topics/themes						Theoretical lens/ main concept/ model	Most frequent keywords	Label
		HSCM	Performance measure-ment	HSC design	Emergent tech-nol-ogy—big data and social media	Partnership, relationship and collabo-ration	Sustain-ability			
189	Dubey and Gunasekaran (2016)			X				X		Sustainable humanitarian supply chain (agility, adapt-ability and alignment)
189	Dubey et al. (2019c)							X		Commit-ment-trust theory
180	Alray et al. (2018)		X						X	Dynamic capability view
178	Dubey et al. (2019b)						X		X	Organi-zational information processing theory (OIPT)

Table 7 (continued)

TLS	Cited references	Main topics/themes						Theoretical lenses/ main concept/ model	Most frequent keywords	Label
		HSCM	Performance measurement	HSC design	Emergent technology—big data and social media	Partnership, relationship and collaboration	Sustainability			
169	Dubey et al. (2018)		X							Resource-based view (RBV) and Contingency Theory (CT)
142	Bealt et al. (2016)				X					SCM collaborative partnerships
112	Papadopoulos et al. (2017)				X				X	Resilience in supply chain networks

Table 7 (continued)

TLS	Cited refer-ences	Main topics/themes						Theoretical lenses/ main concept/ model	Most frequent keywords	Label
		HSCM	Performance measure-ment	HSC design	Emergent technol-ogy—big data and social media	Partnership, relationship and collabo-ration	Sustain-ability			
104	Banomyong et al. (2019)	X	X							Humani-tarian operations, Humani-tarian logistics and Humani-tarian supply chain Per-formance
91	Moshitari (2016)					X			X	Inter-organi-zational fit and Relation-ship man-agement capability perspec-tives/ Relational View

Table 7 (continued)

TLS	Cited refer-ences	Main topics/themes						Theoretical lens/ main concept/ model	Most frequent keywords	Label
		HSCM	Performance measurement	HSC design	Emergent technology—big data and social media	Partnership, relationship and collaboration	Sustain-ability			
83	Akter and Fosso-Wamba (2019)				X					Big data analytics
69	Yoo et al. (2016)				X					Information Diffusion Theory
28	Prasad et al. (2018)				X	X		X		Resource depend-ence theory (RDT)

Table 8 Bibliographic coupling analysis in the humanitarian operations literature: Blue Cluster

TLS	Cited references	Main topics/themes							Theoretical lenses/main concept/model	Most frequent keywords	Label
		Network flow and vehicle routing	Facility location	Inventory management	Healthcare technology—drones	Evacuation	Facility and stock pre-positioning	Resilience			
433	Gupta et al. (2016)	X	X	X		X			Disaster Management from a POM Perspective	Humanitarian logistics (9); Facility location (4); Multi-objective programming (3); Stochastic programming (3)	Healthcare facility location
331	Habib et al. (2016)	X	X	X				X	Optimization models		
265	Alem et al. (2016)	X	X	X					Two-stage stochastic network flow model		
245	Rodriguez-espindola et al. (2018)	X	X					X	Multi-objective optimization and geographical information systems		
223	Boonmee et al. (2017)								Optimization models		

Table 8 (continued)

Cited references	Main topics/themes						Evacuation	Facility and stock pre-positioning	Resilience	Theoretical lenses/main concept/model	Most frequent keywords	Label
	Network flow and vehicle routing	Facility location	Inventory management	Healthcare	Emergent technology—drones	Facility location						
223 Zokaee et al. (2016)	X	X							Robust optimization approach/Mixed integer linear programming (MILP)			
207 Cavdur et al. (2016)		X							two-stage stochastic-integer programming model			
202 Dufour et al. (2018)			X				X		stochastic network flow problem			

Table 8 (continued)

TLS	Cited refer-ences	Main topics/themes						Theoretical lenses/main concept/model	Most frequent keywords	Label
		Network flow and vehicle routing	Facility location	Inventory management	Healthcare	Emergent technology—drones	Evacuation			
200	Tofighi et al. (2016)	X	X				X	X	Two-stage scenario based positional stochastic programming (SBSP)/two-echelon humanitarian logistics network design problem	
192	Charles et al. (2016)	X	X					X	Mixed-integer linear programming model	

Table 8 (continued)

TLS Cited references	Main topics/themes						Theoretical lenses/main concept/model	Most frequent keywords	Label
	Network flow and vehicle routing	Facility location	Inventory management	Healthcare	Emergent technology—drones	Evacuation			
185 Moreno et al. (2016)	X	X	X					Two stochastic mixed-integer programming models/relax-and-fix and fix-and-optimize heuristics/Multiperiod location-transportation problem	
166 Manopimwes and Irohara (2017)	X	X				X	X	Multi-objective stochastic linear mixed-integer programming model	

Table 8 (continued)

TLS	Cited references	Main topics/themes						Theoretical lenses/main concept/model	Most frequent keywords	Label
		Network flow and vehicle routing	Facility location	Inventory management	Healthcare technology—drones	Evacuation	Facility and stock pre-positioning			
157	Perez-Rodriguez and Holguin-Veras (2016)	X	X						Welfare economic concepts/heuristic solution approaches	
138	Pradhananga et al. (2016)	X	X				X		Welfare economic concepts/three-echelon network model	
133	Chowdhury et al. (2017)	X	X	X	X				Two-phase continuous approximation (CA) model	
121	Ahmadi-Javid et al. (2017)		X		X				Healthcare facility (HCF) location problem/optimization models	

Table 8 (continued)

TLS	Cited references	Main topics/themes						Resilience	Theoretical lenses/main concept/model	Most frequent keywords	Label
		Network flow and vehicle routing	Facility location	Inventory management	Healthcare	Emergent technology—drones	Evacuation				
92	Fahimnia et al. (2017)		X	X	X		X	Stochastic bi-objective supply chain design model/ ϵ -constraint and Lagrangian relaxation			
39	Samani et al. (2018)	X	X	X	X			Multi-objective mixed integer linear programming model/two-stage stochastic programming and possibilistic programming approaches			

Table 8 (continued)

TLS Cited refer-ences	Main topics/themes							Theoretical lens/main concept/model	Most frequent keywords	Label
	Network flow and vehicle routing	Facility location	Inventory management	Healthcare	Emergent technology—drones	Evacuation	Facility and stock pre-positioning			
14 Nedjati et al. (2016)	X			X						Aerial distribution system optimization model

the cluster also dealt with the optimization of physical distribution in humanitarian aid as a central theme, with mathematical solutions to the classic problems of network flow and routing, facility location and inventory management. But new themes have also emerged, such as disruption in humanitarian supply networks, and equity as an optimization goal (Noyan et al., 2016; Ransikarbum & Mason, 2016a, 2016b). Thus, the categories that emerged inductively for the "Main topics/themes" dimension of the yellow cluster were: Network flow and Vehicle routing, Facility location, Inventory management, Network/Supply chain disruptions and restoration, and Equity-based solution. The most frequent keywords in the yellow cluster, with their respective repetition figures, were as follows: Humanitarian logistics (5), Disaster relief (3), Multiple objective optimization (2), Equity (2) and Optimization (2). In view of the content analysis carried out, the yellow cluster was labeled "Network flow restoration optimization". The article in this cluster that stood out the most, with the greatest total link strength (TLS=257) was Gutjahr and Nolz (2016), which reviewed the literature on the application of multi-criteria optimization in disaster operations. The most significant journals in the yellow cluster were "European Journal of Operational Research", with 30% of articles, and "Annals of Operations Research" and "Transportation Research Part E" with 20% of the works each, confirming quality and tradition in operational research.

In the purple cluster, there was a predominance of issues related to Supply Chain Management in the humanitarian context, with an emphasis on partnership and collaboration (Bealt et al., 2016; Dubey et al., 2019b; Moshtari, 2016; Papadopoulos et al., 2017), aiming to improve the relationship among actors in humanitarian aid networks, and use emerging technologies (Akteer and Fosso-Wamba, 2019; Dubey et al. 2019b; Papadopoulos et al., 2017; Prasad et al., 2018; Yoo et al., 2016), such as the use of social media like Facebook and Twitter as data sources in disaster situations, and, mainly, Big Data Analytics, as a promising tool in humanitarian chains. Thus, through content analysis, the following categories were identified for the dimension, "Main topics/themes" in the cluster: Humanitarian Supply Chain Management (HSCM), Performance measurement, Humanitarian Supply Chain (HSC) Design, Emergent Technology—Big Data and Social media, Partnership, Relationship and Collaboration, Sustainability, Swift trust and Resilience. In the purple cluster, the best consolidated theories used as theoretical lenses of the articles under analysis were: Dynamic capability view, Organizational information processing theory (OIPT), Relational View, Information Diffusion Theory (IDT), Commitment-trust theory, Resource-based view (RBV), Contingency theory (CT) and Resource Dependence Theory (RDT). Regarding the methodological approach, the articles in the cluster generally used literature review, survey and multivariate analysis methods. The most frequent keywords with the respective number of repetitions were: Big Data (5), Humanitarian supply chain (5), Humanitarian logistics (3), Humanitarian operations (3), Resilience (2), Collaboration (2) and Swift trust (2). In view of the characteristics raised in the content analysis, the purple cluster was labeled as "Relationship management and Big Data applications in HSC".

The most prominent article in the purple cluster, for presenting the highest total link strength (TLS=573), was Behl and Dutta (2019), with a thematic literature review on humanitarian supply chain management. Another aspect highlighted in the purple cluster is that Rameshwar Dubey is the first author of four emerging articles (Dubey & Gunasekaran, 2016; Dubey et al., 2018; Dubey et al., 2019b, c), which may point to an emerging intellectual leadership in the area under analysis. Finally, the journal "Annals of Operations Research" was revealed as the predominant source of the purple cluster with 42.9% of the papers.

Regarding the blue cluster, there was a predominance in the proposal of solutions to the problem of facility location (which is also the problem most addressed in humanitarian operations, in general), and with the distribution of humanitarian supplies related to the health area (Ahmadi-Javid et al., 2017; Fahimnia et al., 2017; Nedjati et al., 2016; Samani et al., 2018), such as hospital supplies, medications, vaccines and blood bags. In addition, the inclusion of proposals for the use of new technologies in humanitarian operations is highlighted, such as unmanned aerial vehicles (UAV) or drones (Chowdhury et al., 2017; Nedjati et al., 2016), which can be very useful in accessing areas severely affected by disasters for delivery of supplies and searching for victims. Then, the following categories were identified for the dimension, "Main topics/themes" for the blue cluster: Network flow and Vehicle routing, Facility location, Inventory management, Healthcare, Emergent Technology – Drones, Evacuation, Facility and Stock Pre-positioning, and Resilience. The most frequent keywords and the respective number of repetitions were: Humanitarian logistics (9), Facility location (4), Multi-objective programming (3) and Stochastic programming (3). In view of the content extracted, the blue cluster was named "Healthcare facility location". The article most conspicuous in the blue cluster due to its total link strength (TLS=433) was Gupta et al. (2016), with a systematic literature review of the disaster management from a POM perspective. Finally, the most significant journals in the blue cluster were "European Journal of Operational Research" and "International Journal of Disaster Risk Reduction", with 15.8% of the papers each.

Table 9 Sources of articles analyzed using the bibliographic coupling technique

Paper sources	Count	Percentage
Annals of Operations Research	8	18.6
European Journal of Operational Research	6	14.0
International Journal of Production Economics	4	9.3
International Journal of Disaster Risk Reduction	3	7.0
Computers & Operations Research	2	4.7
International Journal of Production Research	2	4.7
Journal of Operations Management	2	4.7
Production and Operations Management	2	4.7
Transportation Research Part E	2	4.7
Transportation Science	2	4.7
Applied Mathematical Modelling	1	2.3
Computers & Industrial Engineering	1	2.3
International Journal of Logistics Research and Applications	1	2.3
Journal of Cleaner Production	1	2.3
Journal of Humanitarian Logistics and Supply Chain Management	1	2.3
Mathematical Problems in Engineering	1	2.3
Natural Hazards	1	2.3
Omega—The International Journal of Management Science	1	2.3
Production Planning & Control	1	2.3
The International Journal of Logistics Management	1	2.3
Total Geral	43	100

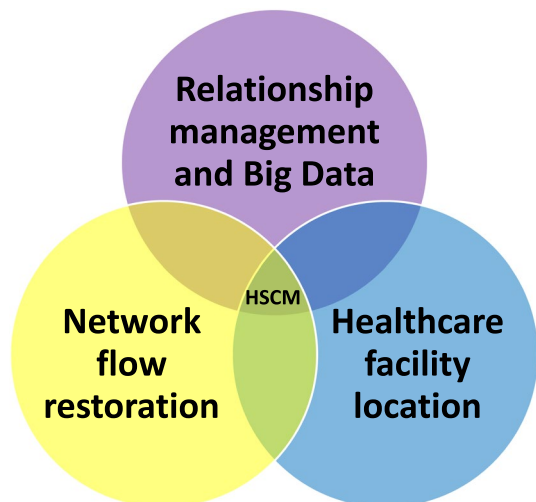
When considering the sources of all the papers analyzed in the bibliographic coupling, according to Table 9, it is possible to verify that they are all top-ranked journals, strengthening the representativeness of these emerging works. As noted, "Annals of Operations Research" stood out as the predominant source with 18.6% of the articles, becoming consolidated as an emerging influential source for the field of study under analysis.

It was possible to observe that most of the emerging works presented by the analysis of bibliographic coupling had a quantitative approach, these being the majority in the field of OR/MS. This helps to understand the evolutionary path of this research field and its trends for future research, given that the method of analytical and applied research with the development of mathematical modeling for optimization has become dominant in the area. However, other methods and approaches remain important for the development of theories in the field, which is what was demonstrated by the relevance presented by the articles in the purple cluster. Finally, Fig. 8 presents the most significant emerging issues in humanitarian operations by summarizing the labels of each cluster.

3.3.3 Keyword co-occurrence analysis

To answer the third research question, the complete set of data extracted from the WoS database was loaded into the VOSviewer software, selecting as the type of analysis, "co-occurrence", marking the type, "keywords of the author" and choosing the item, "total count" as the counting method, which means that the software considers that each keyword has the same weight, regardless of the number of keywords contained in each article (Van Eck & Waltman, 2010). A "thesaurus file", prepared by the authors, was also loaded into the software. For this type of analysis, this step is important, as there are several keywords with small variations (in the singular and plural, for example) or with the same meaning, which need to be standardized for the algorithm to interpret as a single word and do a proper count. In sequence, the software computed 3123 keywords, and to allow an intelligible visualization of the map, the minimum number of 8 occurrences for each keyword was used as a parameter, resulting in 76 keywords that met the criteria, and these were reduced to 67 after reading the thesaurus file provided by the

Fig. 8 Emerging themes in humanitarian operations



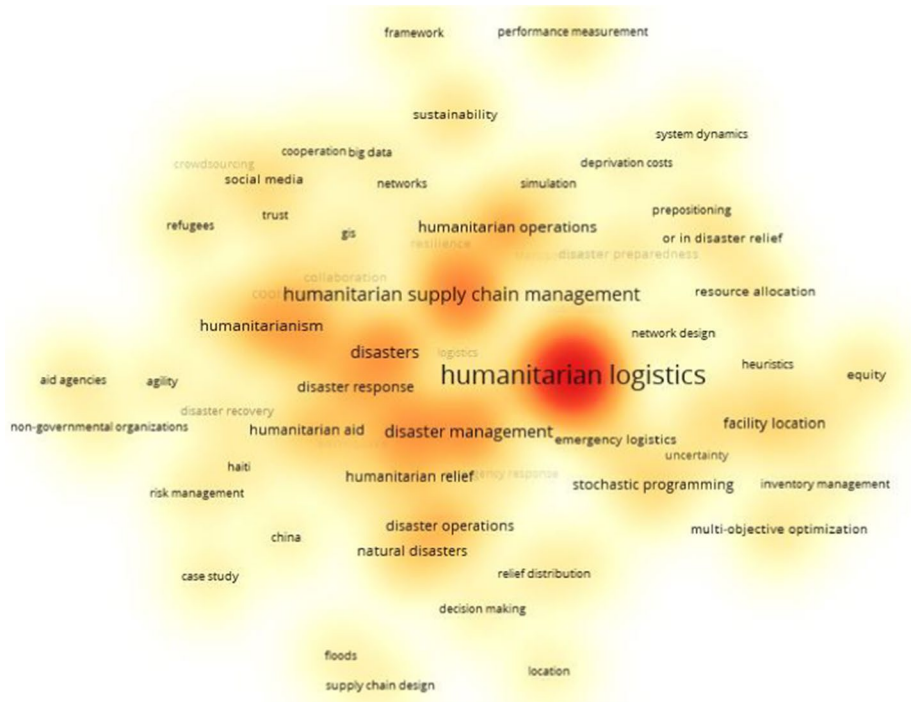


Fig. 9 Keyword co-occurrence analysis of humanitarian operations literature

selected software. The map showing the 67 keywords with the highest occurrence in the field can be seen in Fig. 9. We opted for representation in the form of a heat density map, that is, the denser the orange color, the more important the item. In visualization, the importance of the element is also proportional to the size and visibility of the letters that identify it, according to the attribution of the adopted software algorithm.

As expected, the term “humanitarian logistics” was the most frequent with 379 occurrences, and, therefore, more centralized and denser in color. Also, in the central nucleus, the words “humanitarian supply chain management” with 116 occurrences, “disasters” with 82 repetitions, “disaster management” with 80 occurrences, and “disaster relief” with 77 repetitions are also easily seen. On the map, one can see the consolidation of terms that were part of the discussion on humanitarian supply chain management, such as “coordination”, “collaboration”, “sustainability” and “agility”. It is also possible to identify the presence of terms that referred to humanitarian logistics issues, which have already been comprehensively addressed by the literature under analysis, such as “inventory management”, “facility location”, “pre-positioning”, “resource allocation” and “vehicle routing”, which generally deal with mathematical modeling for “optimization” of these distribution management activities. The map also showed, situated in the intermediate positions, the terms referring to the topics that were consolidating in the discussion of articles in the area as research trends, such as “resilience”, “sustainability”, “social media”, “deprivation costs” and “equity”.

To expand the analysis of the co-occurrence of keywords, the proposal by Courtil et al. (1984), classifying the keywords in “central poles”, “intermediate poles” and

"peripheral poles", was adopted. The central poles present the keywords that occurred most frequently, identifying the general interest in the research area (Courtial et al., 1984). The intermediate poles present keywords with medium frequency, describing intermediate interests with a series of specific issues (Courtial et al., 1984). The peripheral poles present keywords less frequently, indicating the specific issues of interest in the area (Courtial et al., 1984). The total link strength (TLS) calculated by the VOSviewer was used to classify the keywords in the three criteria mentioned above. Thus, the central poles presented the keywords with TLS between 102 and 420; the intermediate poles included the keywords with TLS in the range of 25–64; and, finally, the peripheral poles included the keywords with TLS between 7 and 24, as shown in Fig. 10. Therefore, this figure presents the main topics associated with the conceptual structure of the humanitarian operations field in a structured form.

4 Discussion

Through an integrated analysis of bibliometric techniques used for co-citation and bibliographic coupling, it is possible to understand the dynamics of the evolution of themes (Zupic & Cater, 2015) in the humanitarian operations field. This logic is due to the fact that co-citation identified the most important works of HO that form the basis of the field. The bibliographic coupling identified emerging works that represent hot research topics. Thus, the basic intellectual structure of HO is more homogeneous, with only two clusters—Humanitarian Supply Chain Management and Distribution Optimization in Humanitarian Logistics—that represent the fundamental foundations and concepts of the research field, with emphasis on the possibility of cross-learning between humanitarian and commercial supply chains, and in efficiency to improve logistics performance. The emerging intellectual structure in HO is more diversified, comprising three clusters—Relationship

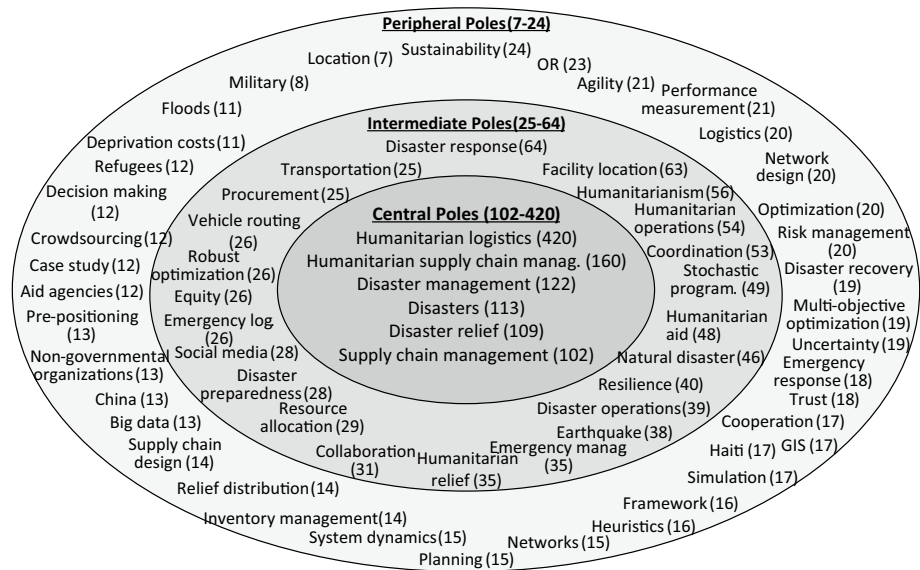


Fig. 10 Classification of keyword poles in the humanitarian operations literature according to the TLS

Management and Big Data in HSC, Healthcare facility location, and Network flow restoration optimization, which indicate the subjects with growing interest in the area. The methodologies used in the emerging works are predominantly quantitative, with emphasis on OR/MS, which has become consolidated as one of the main traditions in the research field. In this dynamic of the HO field, it is also possible to observe the emergence of researchers who were not part of the basic intellectual structure, but who have very popular recent works.

It is observed that the main problems addressed in the optimization of humanitarian logistics (network flow and vehicle routing, location of facilities and stock management) have been the same over the years. However, previously they focused on the efficiency and performance of operations (Haghani & Oh, 1996; Ozdamar et al., 2004), due to the resources of humanitarian organizations being very scarce. More recently, the focus has been on multiple objectives, incorporating issues of equity (Noyan et al., 2016; Ransikarbum & Mason, 2016a) and deprivation costs (Perez-Rodriguez & Holguín-Veras, 2016; Pradhananga et al., 2016) in the result dimension of mathematical modeling. The relationship among stakeholders in the humanitarian aid network has also evolved from a focus on coordination (Balcik et al., 2010; Kovács & Spens, 2009) and public–private partnerships (Tomasini & Van Wassenhove, 2009a) to including, in emerging work, other forms of collaborative relationships (Bealt et al., 2016; Moshitari, 2016), and swift trust (Dubey & Gunasekaran, 2016; Papadopoulos et al., 2017) among humanitarian partners in the supply chain. Exploring the concept of swift-trust, Dubey et al. (2019c) used the Commitment-trust theory (Morgan & Hunt, 1994), to explain how swift-trust facilitates coordination through commitment in the humanitarian context. With further regard to the emerging articles, Moshitari (2016) also showed, through a theoretical approach based on Relational View (Dyer & Singh, 1998), that relationship management capabilities (coordination, communication and bonding skills) are more vital than inter-organizational fit (similar missions, objectives and operational procedures) in the context of humanitarian operations.

It is also possible to note that the discussion on the theme of the HSC design had an emphasis on identifying its properties. In the articles of the basic intellectual structure, Van Wassenhove (2006) indicated, through an overview, that an HSC must be agile, adaptable and aligned to improve its performance. Then, Oloruntoba and Gray (2006) explored more specifically and found that the HSC design should be based on agile supply chain concepts. In the emerging works, Dubey and Gunasekaran (2016) explored aspects of sustainability linked to the HSC design, and concluded that agility, adaptability and alignment are important characteristics for the design of humanitarian aid networks. Finally, Altay et al. (2018) advanced the discussion of HSC design by suggesting supply chain agility (SCAG) and supply chain resilience (SCRES) as dynamic resources that contribute to HSC performance, using Dynamic Capabilities View—DCV (Teece et al., 1997) as a theoretical lens.

The concept of resilience applied to humanitarian operations appeared in the basic articles of this study (Van Wassenhove & Pedraza Martinez, 2012), with a focus on the need for resilience in the affected communities. In the emerging articles, Duhamel et al. (2016) and Tofighi et al. (2016) advanced the discussion, suggesting the humanitarian aid as a response mechanism that could increase communities' resilience and reduce loss of life. More recently, Papadopoulos et al. (2017) used an integrated structure that demonstrated interaction of different levels of resilience in the context of disasters: supply chain resilience, critical infrastructure resilience, community resilience and resource resilience. In addition, Dubey and Gunasekaran (2016) and Altay et al. (2018) emphasized aspects of humanitarian supply chain resilience and their contribution to improving operations performance. However, there is still a need to develop research on the topic of resilience from

the perspective of humanitarian supply chains (Altay et al., 2018; Dubey et al., 2014, 2020; Singh et al., 2018).

Another theme that has drawn a lot of attention in emerging works is the role of emerging technologies in humanitarian operations, with emphasis on Big Data, social media and drones. Yoo et al. (2016) highlighted that humanitarian organizations are increasingly using internet-based social media (such as Twitter), using in their research the Information Diffusion Theory to demonstrate that social media networks are effective in transmitting information during humanitarian crises. Papadopoulos et al. (2017) innovated in their research by using Big Data concepts based on 36,422 items collected from social media (Twitter, Facebook, WordPress, Instagram, Google and YouTube), to identify swift trust, public–private partnerships, and information-sharing, such as constructs linked to resilience in supply chain networks. Dubey et al. (2018) identified a significant influence of big data on the visibility and coordination of HSC, using the theoretical lenses of Resource-based view (RBV) and Contingency Theory (CT). Prasad et al. (2018) demonstrated the link between Big Data analysis and Resource Dependency Theory—RDT (Pfeffer & Salancik, 1978) to achieve superior results in humanitarian supply chains. Dubey et al. (2019b) explained, through the Organizational Information Processing Theory—OIPT (Galbraith, 1974), how Big Data analysis capability relates to improving trust and collaborative performance among organizations involved in humanitarian operations. Akter and Fosso Wamba (2019) confirmed the importance of Big Data for visualizing, analyzing and predicting disasters through a literature review. As such, the topic of Big Data is on the rise in HO research, but more research is still needed, mainly to identify how unstructured data from social media and Big Data applications can contribute to disaster prevention and preparedness, increasing community resilience and preserving lives. Another emerging technology in HO are drones (or UAVs), which appear more linked to the healthcare operations cluster, with articles by Nedjati et al. (2016) and Chowdhury et al. (2017). This association really makes sense, for, as indicated by the authors, drones can be useful for locating people injured in catastrophes in inaccessible areas, in addition to delivering essential items, such as medicines and first aid. However, we believe that more research is needed to show how drone technology could be scalable in disaster operations. Another line of research could also be explored linking the benefit of drones in pandemic situations (such as COVID-19), which could, for example, be used to deliver critical items and contribute to social isolation needs. Another positive point verified in the emerging clusters is the extensive use of grounded theories to explain the work in HO, which was a need reported by Tabaklar et al. (2015) and Oloruntoba et al. (2019), who had attention to the need to borrow from other theoretical perspectives and grand theories. Therefore, another advantage of the integrated use of bibliometric techniques for scientific mapping of a field of study is to understand the dynamics of recurrent themes over time, making it possible to quickly understand their evolution, based on the most significant works in the area.

4.1 Implications for research

As previously mentioned, there are already some articles that use a literature review approach in humanitarian operations, humanitarian logistics and humanitarian supply chains, which aim to broaden the understanding of the literature in this research field. However, the scope of analysis of previous studies are specific, and none use bibliometric mapping as the main methodology, which allows visualization and grouping of the most significant works in the research field (Van Eck & Waltman, 2014) to understand their state

Table 10 Comparison of this research with previous literature reviews

Article	Methodology	Scope
Altay and Green (2006)	Literature review	OR/MS in disaster operations management
Kovács and Spens (2007)	Literature review	Humanitarian logistics
Pettit and Beresford (2009)	Literature review	Critical success factors of humanitarian logistics
Natarajathinam et al. (2009)	Literature review	Supply chain management (SCM) in times of crisis
Overstreet et al. (2011)	Literature review	Humanitarian logistics, sudden onset disasters
Kunz and Reiner (2012)	Meta-analysis	Humanitarian logistics
Abidi et al. (2014)	Systematic literature review	Performance measurement and management in humanitarian supply chains
Anaya-Arenas et al. (2014)	Systematic literature review	Emergency logistics
Leiras et al. (2014)	Systematic literature review	Humanitarian logistics
Nurmala et al. (2017)	Systematic literature review	Partnerships between humanitarian organizations and business corporations in managing humanitarian logistics
Bealt and Mansouri (2018)	Systematic literature review	Community-driven humanitarian logistics
Behl and Dutta (2019)	Systematic literature review	Humanitarian supply chain management
Banomyong et al. (2019)	Systematic literature review	Humanitarian operations, humanitarian logistics and humanitarian supply chain performance
Jabbour et al. (2019)	Systematic literature review	Humanitarian logistics and humanitarian supply chain management
Gupta et al. (2019)	Systematic literature review	Big data in humanitarian supply chains
Akter and Fosso-Wamba (2019)	Systematic literature review	Big data in disaster management
Mishra et al. (2019)	Systematic literature review	Simulation modeling in disaster management
Dubey et al. (2019a)	Literature review	Disaster relief operations
Modgil et al. (2020)	Systematic literature review	Quality in humanitarian operations and disaster relief management
Fosso-Wamba (2020)	Bibliometric approach: performance analysis	Humanitarian supply chains
This paper	Bibliometric approach: scientific mapping	Humanitarian operations, humanitarian supply chain and humanitarian logistics

of the art and the conceptual synthesis of knowledge (Petticrew & Roberts, 2006; Rowley & Slack, 2004). Therefore, to clearly demonstrate the differentiated contribution of this article, Table 10 was prepared with a comparison of previous works in this research category in the field of study under analysis.

Thus, as can be seen in Table 10, this paper is unique in using bibliometric mapping as the main methodology, in addition to using a broader scope than the others, enabling understanding of the intellectual structure of this research field.

4.2 Implications for practice

As a practical contribution, the article offers HO professionals identification of subthemes in each of the clusters presented, and may serve as insights for the application of tools and techniques to improve the work they develop. For example, humanitarian organizations and government agencies may be encouraged to apply emerging technologies (such as Big Data) to improve their operations and provide greater transparency to donors and other members of the humanitarian aid chains. In addition, indications for future research could encourage professionals working in HO to establish partnerships with researchers for the development of empirical projects.

5 Limitations and future research

A limitation that can be pointed out in this paper is that, despite using a more objective quantitative approach, there was also use of qualitative content analysis of the works, which is more subjective. However, to minimize the risk of researcher interpretation bias, the practice of reviewing the analyses of each researcher was adopted so that a consensus was reached. The keyword, co-occurrence approach also has a certain limitation, since the quantitative method of word count is not able to distinguish the context in which the keywords are used in the original articles. For example, the keyword, “resilience” appears with a connecting force that places it as an intermediate research pole, although, in the field under study, this word has different connotations, which may mean resilience of communities in the face of disasters (Papadopoulos et al., 2017), resilience of workers working in disaster environments (Khatri et al., 2019), and supply chain resilience (commercial or humanitarian) in the face of disaster impacts (Dubey et al., 2020; Papadopoulos et al., 2017). However, it is understood that this does not remove the interest in the topic for future research, as there is a lack of studies that better clarify the meanings of resilience in the context of disasters (Singh et al., 2018). The same logic of ambiguity follows the keyword, case study, which, in the field of research under analysis, can mean a qualitative methodology that aims to generate theories (Olaogbebikan & Oloruntoba, 2019), or just a contextual choice for obtaining data to conduct optimization modeling in operational research (Turkes et al., 2019). Another limitation for analyzing the co-occurrence of keywords is the existence of synonyms among them. To minimize this problem, a thesaurus file was introduced to be executed in the VOSviewer software, but the decision regarding the words that would compose such a thesaurus file came from judgment by the researchers who had sought to discuss and reach a consensus to avoid bias.

Regarding the recommendations for future research, we reinforce that the themes presented in the bibliographic coupling approach represent the emerging research topics in the area, and, therefore, need to be developed. Among these emerging themes, we highlight the

use of emerging technologies (Big Data, social media and drones), forms of partnership and healthcare, applied to humanitarian operations. Specifically regarding the humanitarian logistics cluster in healthcare, despite it being an emerging topic, we believe that growth will potentially be increased due to the coronavirus (COVID-19) pandemic, which became a global emergency in 2020, requiring responses in the field of humanitarian operations through research. The same logic applies to the topics of the intermediate and peripheral poles of keyword analysis, and therefore need to be better developed, with emphasis on the themes of coordination, resilience, multi-objective optimization, deprivation costs, equity and network or supply chain design, in the context of humanitarian operations and disasters. However, in this type of study, absences also reveal a lack of research on certain topics. In this sense, in relation to the types of disasters, research on man-made or technological disasters, natural disasters with a slow onset and disasters with less impact, but which have occurred more frequently, is still lacking. Regarding the phases of the disaster cycle, the mitigation and preparedness phases deserve more attention. From the perspective of the research method, there is still a lack of conceptual and empirical research. Regarding the stakeholder perspective, there is a lack of studies on the role of governmental organizations in the context of disaster operations. Therefore, all of these topics are recommendations for future research for development of the HO area. Finally, in view of the analysis carried out, we have composed the following questions for future research:

- How can OR/MS-based modeling contribute to response to disruptions in networks and supply chains (humanitarian and commercial) through the impact of disasters and pandemics?
- How can unstructured data from social media and Big Data applications contribute to disaster prevention and preparedness, thereby increasing community resilience?
- How can the concepts of Big Data, Blockchain and social media be transformed into practical tools to contribute to the improvement of disaster preparedness and response strategies, and thus effectively save lives?
- What capabilities should be developed to make humanitarian supply chains more resilient? Are there specific resilience capabilities or strategies for dealing with disasters with systemic effects, such as the COVID-19 pandemic?
- How can the properties of humanitarian supply chain design be adapted to various types of disasters and threats?
- How can humanitarian logistics tools contribute to strengthening health supply chains in times of pandemics? How are health supply chains responding to the disruption caused by the COVID-19 pandemic?
- How can drone technology be made scalable for use in disaster response operations? In addition to use in response to disasters, in what other phases or activities of humanitarian operations can drones be used?

6 Conclusion

Although there have already been some literature reviews on humanitarian operations, there was still no bibliometric study with a scientific mapping approach that identified the intellectual structure of this research field. Therefore, this work's contribution is an unprecedented proposal that allows understanding of the intellectual structure of the humanitarian

operations research field, first identifying its fundamental basis, and, later, the emerging research trends in the area.

In order to answer RQ1, we present the general cognitive structure of humanitarian operations, which is divided into two clusters: Distribution Optimization in Humanitarian Logistics (DOHL) and Humanitarian Supply Chain Management (HSCM). The articles in the DOHL cluster are predominantly analytical, with application of simulation and mathematical modeling to solve logistical distribution problems in the context of humanitarian crises. The works of the HSCM cluster have conceptual predominance, encompassing issues that cover the humanitarian aid chains and their various members. We also proposed a conceptual framework that illustrates the general cognitive structure, which we call "HO knowledge building".

As for the emerging intellectual structure in humanitarian operations, which responds to RQ2, three clusters were identified: Relationship Management and Big Data in HSC, Healthcare facility location, and Network flow restoration optimization. Such themes appear as trends identified in recent articles and can be better explored, serving as a starting point for future studies. In addition, analytical research methods based on mathematical modeling and operational research have become consolidated as the predominant methodology in this study field. In order to answer RQ3, the following keywords were identified as the main conceptual building blocks of the literature under study: Humanitarian logistics, Humanitarian supply chain management, Disaster management, Disasters, Disaster relief, and Supply chain management. This result confirms the more mature topics that have been addressed in the literature under analysis over the years. Finally, it is understood that, just as a map is a visual instrument that serves to guide users, the literature mapped in this work can serve as a guide for researchers and students to develop further research in the area.

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Declarations

Conflict of interest The authors declare that they have no conflict of interest.

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