Iran Red Crescent Med J. 2020 January; 22(1):e99920. doi: 10.5812/ircmj.99920.

Published online 2020 February 2. **Systematic Review**

Factors Affecting the Prepositioning of Relief Items for Natural Disasters: A Systematic Review

Mehrab Sharifi-Sedeh [1, 2, *], Ali Ardalan [1], S. Ali Torabi [3], Kiyoumars Allahbakhshi [4] and Davoud Khorasani-Zavareh [5, **]

[1] School of Public Health, Tehran University of Medical Sciences (TUMS), Tehran, Iran
[2] Member of Research Center for Health Management in Mass Gathering, Red Crescent Society of the Islamic Republic of Iran, Tehran, Iran
[3] School of Industrial Engineering, College of Engineering, University of Tehran, Tehran, Iran
[4] Department of Health in Disasters and Emergencies, School of Public Health and Safety, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[5] School of Public Health and Safety, Shahid Beheshti University of Medical Sciences, Tehran, Iran

[*] *Corresponding author*: School of Public Health, Tehran University of Medical Sciences (TUMS), Tehran, Iran. Email: mehrabsharifi@gmail.com
[**] *Corresponding author*: MD, Ph.D., Associate Professor, Workplace Health Promotion Research Center (WHPRC), Shahid Beheshti University of Medical Sciences, Tehran, Iran. Postal Code: 19835-35511, Tel: +98-2122432040, Email: davoudkhorasani@gmail.com

Received 2019 December 03; **Accepted** 2020 January 14.

Abstract

Context: Humanitarian logistics aims to reduce the suffering of disaster victims by fulfilling their immediate needs. A key component of humanitarian logistics is the prepositioning of relief items (such as water and food) for effective emergency response.
Objectives: This study aimed to explore factors affecting the prepositioning of relief items for natural disasters.
Data Sources: This was a systematic review. Relevant articles were retrieved from Google Scholar, PubMed, Web of Science, and Scopus databases. We also assessed other gray literature.
Data Extraction: Data were summarized and analyzed through thematic content analysis. Overall, 22 final articles were included in the study. Articles that referred to the prepositioning of relief items were included in the study.
Results: Factors affecting the prepositioning of relief items were categorized into four main categories and eight sub-categories. These categories included site selection, preparation, and management of warehouse (with two sub-categories of warehouse site selection, warehouse workforce); risk management studies (with two sub-categories of uncertainty, and demand estimation); infrastructures (with two sub-categories of transportation infrastructures, and other infrastructures); and financial and sociopolitical factors (with two sub-categories of financial problems and limitations sociopolitical factors).
Conclusions: Appropriate identification of factors that affect relief-item prepositioning can help decision-makers design appropriate models for prepositioning.

Keywords: Disaster, Humanitarian Logistics, Prepositioning, Relief Items, Supply Chain

1. Context

Disasters cause heavy damages and incur heavy financial costs. They caused more than eight million human deaths in the twentieth century (1). Moreover, 6,637 disasters happened from 1974 to 2003, which affected 5.1 billion people and caused 1.38 trillion dollars of financial damage (2). Disasters and Emergency necessitate adequate preparedness for rapid and effective response (3, 4). Limited accessibility of relief items during disasters can result in ineffective emergency response, thereby increasing human suffering and death. Humanitarian organizations can promote their disaster preparedness and emergency response capacity by ensuring the accessibility of relief items (5). Therefore, prepositioning of relief items (PRI) is considered an effective method for promoting disaster preparedness (3, 4). Pre-disaster planning and PRI have significant roles in reducing the time of relief item arrival at disaster areas (6, 7). Prepositioning of relief items is a key component of humanitarian logistics and supply chain (6, 8). Humanitarian organizations attempt to buy and preposition relief items in strategic warehouses (1).

Relief operation, humanitarian logistics, and PRI face many different challenges. Some of these challenges include damages to transportation networks due to disasters, difficulties in timely arrival at disaster areas, difficulties in supplying relief items to disaster victims, safety problems, lack of professional staff and high level of staff turnover, changes in logistics capacities, unclear request for relief items, limited access to reliable information

about demands and resources, and interference of governments and citizens (9-11). Moreover, PRI can be affected by many different factors. Yet, no comprehensive study has been conducted on these factors. Studies in the area of humanitarian logistics also insularly addressed some aspects of these factors.

There are many articles in the field of humanitarian logistics; however, fewer of them referred to the factors affecting pre-positioning. Examples of these factors are relief item warehousing sites (12), warehouse characteristics, the necessary number of relief items for prepositioning (13), sociopolitical aspects (14, 15), as well as scenarios in planning for the uncertainty situation (16). The present study was carried out to address these gaps. The aim of the study was to explore factors affecting PRI for natural disasters. There are two approaches to manage warehouse, including before and after disaster, which are controversial. Articles related to warehouse management before disasters focused primarily on long-term prepositioning problems related to sudden onset of disasters, while those related to warehouse planning varied dramatically. They showed the disasters and their problems, as well as the warehousing decision items (17).

2. Methods

As a systematic review, this study was conducted from February 2018 to January 2019 based on the Cochrane recommendations for systematic reviews and the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guideline (18).

2.1. Data Sources

An online search was performed in the Google Scholar, PubMed, Web of Science, and Scopus databases. Moreover, we assessed books and reports published by humanitarian organizations such as the World Health Organization, the International Committee of Red Cross, the International Federation of Red Crescent, UNICEF, and the Hanken School.

2.2. Search Strategy

The search strategy was developed based on the comments of librarians. Then, the aforementioned databases were searched using appropriate syntax of relevant keywords. The keyword search was done in the title, abstract and keywords of the articles. For instance, the syntax for searching the PubMed database was as the following:

[Logistic* OR “organization and administration” OR “organizational management” OR “administrative structure” OR “organizational structure” OR “administrative management” AND "humanitarian" OR “Relief Work” AND supply* OR “food supply” OR “water supply” OR “supply and distribution” OR “Food Insecurity” AND Disaster* OR “Natural Disaster” AND “Disaster Planning” OR” Disaster Relief Planning” AND Emergency* OR “Emergency Shelter” OR “Emergency Responder”].

The titles of the retrieved articles were assessed and irrelevant studies were excluded. Data searching was independently done by two of the authors (MS and DKZ). Data analysis done by (MSS and KA). Disagreements between them were resolved by coauthors. Regular weekly meetings with coauthors (KA, AA, and SAT) were reviewed and evaluated.

2.3. Data Collection Process

Retrieved articles were assessed and selected in three steps. In the first step, all retrieved articles were entered the EndNote software and the duplicated records were excluded. Subsequently, the titles of the remained articles were assessed and irrelevant articles were excluded. In the second step, three of the authors (MSS, KA, and DKZ) read the abstracts of the articles and selected relevant articles. In the third step, Tow of the authors (MSS and KA) read the full-texts of the selected articles and selected eligible articles that were directly related to humanitarian logistics and PRI. Quality appraisal of the articles was done using the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist (19). Finally, data on the title, reference, first author, country, population, design, and main results of the selected studies were extracted and inserted into a data extraction sheet. Data collection lasted from February 18 to May 14, 2018.

2.4. Inclusion and Exclusion Criteria

As human logistics is a young science, studies published from 2000 to May 2018 were included. The other inclusion criteria were publication in English and relevance to humanitarian logistics and PRI for natural disasters. Articles related to humanitarian logistics but irrelevant to PRI were not included.

3. Results

In total, 5,218 records were retrieved of which 22 were eligible for the present study (Figure 1). Table 1 shows the characteristics of these 22 articles. Data analysis through thematic content analysis resulted in the development of four main categories and eight subcategories which reflected factors affecting PRI for natural disasters (Table 2). Factors affecting the prepositioning of relief items categorized into four main categories, each contains two subcategories as bellow:

- Site selection, preparation, and management of Warehouse (Warehouse site selection, Warehouse workforce)

- Risk management studies (Uncertainty, Demand estimation)

- Infrastructures (Transportation infrastructures, other infrastructures)

- Financial and sociopolitical factors (Financial Problems, limited Sociopolitical Factors).

3.1. Warehouse Site Selection, Preparation, and Management

Warehousing is one of the main PRI components with significant effects on the flow of relief items before, during, and after disasters (20). Warehouses are strategic places for rapid response to disasters (13).

Table 2. Factors Affecting the Prepositioning of Relief Items for Natural Disasters

Categories, Subcategories	Related Reference
Warehouse site selection, preparation, and management	
Warehouse site selection	(2, 10, 13, 20, 23, 24, 32-34)
Warehouse workforce	(10, 33)
Risk management studies	
Uncertainty	(1, 5, 13, 24-26, 29)
Demand estimation	(10, 21, 25, 29, 35-37)
Infrastructures	
Transportation infrastructures	(2, 13, 32)
Other infrastructures	(2)
Financial and political factors	
Financial problems and limitations	(30, 38)
Sociopolitical factors	(34, 36)

3.1.1. Warehouse Site Selection

Selecting the best physical site for warehousing is one of the most important components of PRI. Relief items need to be prepositioned and warehoused in the best possible sites (2). Warehouses are places for long-term PRI (20). Warehouse site selection is a strategic decision. Studies reported that factors affecting the decision for warehouse site selection include, but are not limited to, land preparation and development costs, building construction costs, public and governmental attitudes towards warehousing, accessibility of transportation services and networks, development potentials, hazards (including fire, robbery, flood, etc.), local workforce, salaries, traffic level around warehouse site, taxes (23, 27, 32, 33), weather conditions (32, 34), geographical topography, vegetation cover, and water source accessibility (34). Another study reported that warehouse site, as well as the type and the quality of relief items that should be prepositioned and warehoused, should be determined based on emergency response scenarios (33). Short distance between warehouses and disaster location significantly reduces response time; however, such closeness is associated with the risk of warehouse damage and destruction due to disasters (23). After warehouse site selection, determining the size of warehouse is another warehouse-related factor affecting PRI (20). Warehouse size is determined based on the size of relief items that are going to be warehoused. The size of relief items, in turn, is determined by the level of demand for relief items at the time of disasters which can be estimated through emergency response scenarios and the results of past disaster analysis.

3.1.2. Warehouse Workforce

PRI necessitates high levels of professional knowledge, skills, and experience (33). Therefore, the shortage of qualified and experienced workforce and high turnover are major challenges and a determining factor for PRI (10).

3.2. Risk Management Studies

Another main factor affecting PRI is risk management studies. Without a risk assessment, the accurate prediction of potential disasters and their effects, adequate preparation for relief and rescue operations, and effective PRI would be impossible. A prerequisite to PRI is to find the types and the locations of potential disasters (13). Assessment of past disasters can also provide valuable information (29). Historical data help develop appropriate scenarios to predict probable disasters, estimate their magnitude, location, and relief item demand, thereby reducing response time (5).

3.2.1. Uncertainty

Complexity and uncertainty are among the key problems of disaster management (1, 3, 24). The level and the site of demand, affected areas, supply sources, and transportation networks need to be considered in uncertainty management (25). Scenario-based models developed based on risk management studies can help identify and reduce uncertainties (1, 26) and determine the levels, sites, and types of demands.

3.2.2. Demand Estimation

Estimating the demands of probable disaster victims is a fundamental challenge in PRI planning. It means the determination of what items are needed, who need them, and where they are needed (35). The general characteristics of demands in disasters are uncertainty, their heaviness, and their unpredictability (36). In disasters, there is

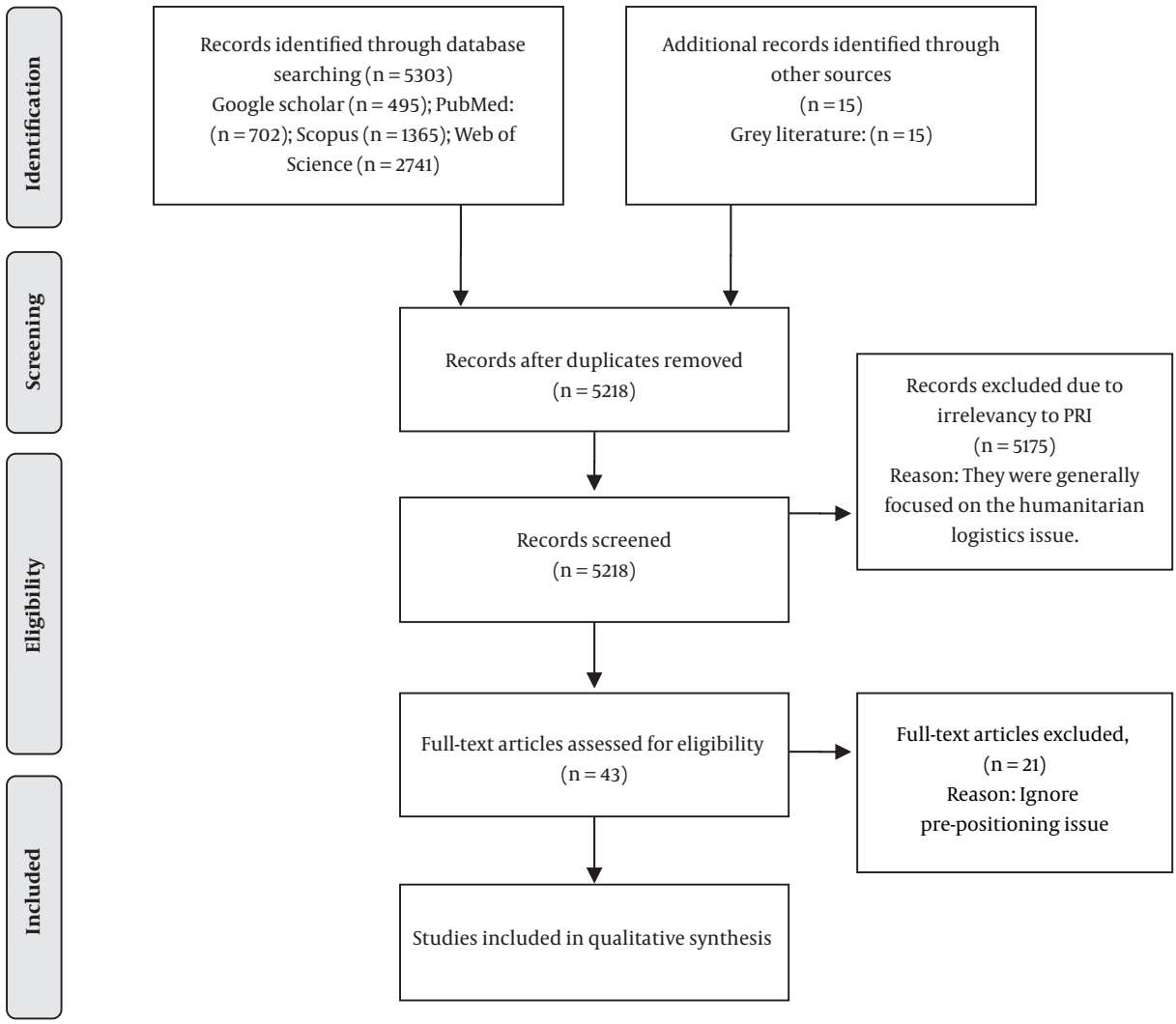

Figure 1. The PRISMA flow diagram of the "Factors affecting the prepositioning of relief items"

an urgent demand for huge amounts of relief items that should be delivered in a short amount of time (21). Yet, demand can almost precisely be predicted based on the data obtained from past disasters (29). Risk management studies can also provide valuable data to develop realistic scenarios and estimate probable demands.

3.3. Infrastructures

Infrastructures are basic structures, places, facilities, and systems that are needed for the operation of a society and include roads, buildings, power sources, etc. Thus PRI-related infrastructures can be divided into two subcategories, namely transportation infrastructures and other infrastructures.

3.3.1. Transportation Infrastructures

The PRI is necessary to ensure relief item availability and accessibility at the time of disasters (13). However, a key factor affecting PRI is to transport the prepositioned relief items to disaster areas. Therefore, transportation infrastructures (such as roads, ports, airports, terminals, and railways) have significant effects on effective PRI (2). Transportation infrastructures can also reduce the time interval between a disaster and the supply of relief items to its victims. On the other hand, poor infrastructures can negatively affect relief and rescue operations (37). For instance, damages to roads are considered as the main relief item supply problem (37). Moreover, the probability of damages to warehouses during disasters highlights the impor-

tance of selecting warehouse sites in safe areas. Therefore, warehouses are usually built far from potential disaster areas and hence, quality transportation infrastructures are needed for the rapid supply of relief items to disaster victims (28).

3.3.2. Other Infrastructures

Besides transportation infrastructures, effective PRI for disasters relies on other infrastructures such as power networks, communication networks, and urban infrastructures (2).

3.4. Financial and Sociopolitical Factors

Financial and sociopolitical factors can also affect PRI. These factors are explained in two subcategories, namely financial problems and limitations and sociopolitical factors.

3.4.1. Financial Problems and Limitations

PRI is a costly process, which necessitates adequate financial resources. Most humanitarian organizations suffer from financial problems and have limited financial resources for PRI (38). Such limitations affect the quantity and quality of PRI (30). Contrarily, adequate financial resources can facilitate PRI (38).

3.4.2. Sociopolitical Factors

Also, PRI is affected by sociopolitical factors such as conflicts, security issues, robbery (30), local suppliers, level of public knowledge, and local culture (34).

4. Discussion

This systematic review explored factors affecting PRI for natural disasters. Findings revealed that these factors included the four main categories of warehouse site selection, preparation, and management, risk management studies, infrastructures, and financial and sociopolitical factors.

Findings revealed warehousing as one of the main factors affecting PRI. Studies highlighted the importance of building warehouses as close as possible to potential disaster areas and large cities in order to increase response effectiveness and shorten response time (2, 22, 28, 31, 39). However, disasters may damage warehouses in disaster areas (17, 23, 39). Therefore, it may be better to build warehouses far from potential disaster areas but close to transportation infrastructures. By this strategy, warehouses and relief items are not damaged by disasters and can be delivered to disaster victims in a short amount of time. Moreover, warehouse site should be selected after considering weather conditions because warmth and humidity in warm and humid areas can gradually destroy relief items (39). Effective warehouse management can also affect PRI. Relief items in warehouses should also be protected against social conflicts, insects, rodents, and fire. Therefore, warehouses should be built in safe places and managed effectively in order to ensure the safety of relief items.

We also found that risk management studies can affect PRI and enhance its effectiveness. Many uncertainties surround PRI, warehousing, demands, and the necessary number of relief items for a disaster. Prediction of probable disasters and using response scenarios can help reduce uncertainties (13) and manage disasters more effectively (7). Mathematical models can also help find realistic solutions for reducing disaster-related uncertainties (1). PRI decision-makers can use scenarios developed based on past disasters to ensure the accurate prediction of relief item demand for future disasters (29). Transportation-related uncertainties also highlight the importance of developing and using scenarios (23). The development of different scenarios for effective disaster prediction and management relies on the results of risk management studies.

Study findings also indicated the shortage of qualified and experienced staff as another factor affecting PRI (37). Warehouse staff need high levels of knowledge, skills, and experience for the accurate arrangement of relief items in warehouses, their proper maintenance, and their effective management (2). Lack of knowledge, skills, and experience may inflict great damages to relief items and warehouses. The shortage of such staff and the high turnover rate of warehouse staff are among the main challenges of PRI for natural disasters (1). A reason for warehouse staff's lack of knowledge and experience and their high turnover may be the fact that they are usually part-time volunteers.

We also found infrastructures as another factor affecting PRI. Disasters can damage infrastructures (40), thereby making warehouses inaccessible and impair response operation. Transportation infrastructures (such as roads, railways, airports, and ports) have a determining role in the timely arrival of relief items at disaster areas and hence, are considered one of the most critical factors in PRI and response operation (34). Potential damages to infrastructures due to disasters cause many uncertainties over PRI and delay relief item arrival at disaster areas. Risk assessment studies and scenarios can help reduce such uncertainties and improve the effectiveness of PRI and response operation (23).

Financial factors also have significant effects on PRI. In developed communities, some relief items can be bought at the site of potential disasters and can be managed

by local staff. However, in under-developed communities, almost all relief items should be bought from other places and managed by non-local experienced staff (34). In both situations, relief item preparation and warehousing impose high costs on humanitarian organizations. On the other hand, a balance is needed between responsiveness and cost-effectiveness. The PRI shortens response time but is associated with high costs. An effective strategy to create a balance between responsiveness and cost-effectiveness is to improve coordination and collaboration among humanitarian organizations and relief item suppliers through flexible contracts for relief item supply. Such strategies not only reduce the need for PRI but also reduce PRI-related costs, promote responsiveness (41), enhance staff and warehouse safety, and improve the quality of infrastructures (30). Other strategies are the establishment of shared warehouses and the development of PRI networks (30).

4.1. Strengths and Limitations

This was among the handful studies which explored factors affecting PRI for natural disasters. The study faced some limitations such as the paucity of studies into PRI and the youngness of humanitarian logistics science.

4.2. Conclusions

Overall, it is to conclude that studies on the pre-positioning of relief items and their influencing factors are seriously necessary. Therefore, we should take these factors into consideration while designing appropriate systems for pre-positioning relief items. We should carry out comprehensive well-designed risk assessment studies to determine potential hazards, vulnerabilities and capacity. After that, we can predict possible hazards, generate scenarios and design a relief preparedness plan and prepositioning relief items for response to disasters. Finding the right answer to the following questions is crucial to prepositioning relief items: what commodity, how much, where, and what to store. Appropriate identification of factors affecting the prepositioning of relief items can help decision-makers design appropriate models for prepositioning. Moreover, we should promote interdisciplinary coordination and collaboration to reduce the costs of procurement and warehousing relief items and to promote responsiveness to potential natural disasters. It is suggested that further qualitative and quantitative studies, focusing on understanding the factors affecting prepositioning in high-risk countries, are needed.

Acknowledgments

We would like to thank all individuals who helped us conduct this study, including the staff and the authorities of the Department of Health in Emergencies and disasters of the Faculty of Health of Tehran University of Medical Sciences, Tehran, Iran, the Faculty of Health and Safety of Shahid Beheshti University of Medical Sciences, Tehran, Iran, and the Faculty of Industrial Engineering of Tehran University, Tehran, Iran. This article was extracted from the first author's Ph.D. dissertation.

Footnotes

Authors' Contribution: The titles of the retrieved articles were assessed and irrelevant studies were excluded. Data searching was independently done by Mehrab Sharifi-Sedeh and Davoud Khorasani-Zavareh. Data analysis done by Mehrab Sharifi-Sedeh and Kiyoumars Alahbakhshi. Disagreements between them were resolved by coauthors. Regular weekly meetings with coauthors (Kiyoumars Alahbakhshi, Ali Ardalan, and Seyed-Ali Torabi) were reviewed and evaluated. Retrieved articles were assessed and selected in three steps. In the first step, all retrieved articles were entered into the EndNote software and the duplicated records were excluded. Then, the titles of the remained articles were assessed and irrelevant articles were excluded. In the second step, three of the authors (Mehrab Sharifi-Sedeh, Kiyoumars Alahbakhshi, and Davoud Khorasani-Zavareh) read the abstracts of the articles and selected relevant articles. In the third step, two of the authors (i.e. Mehrab Sharifi-Sedeh and Kiyoumars Alahbakhshi) read the full-texts of the selected articles and selected eligible articles that were directly related to humanitarian logistics and PRI.

Conflict of Interests: The authors do not have any conflict of interest.

Ethical Approval: This article came from the first authors PhD dissertation approved by the Ethics Committee of Tehran University of Medical Sciences, Tehran, Iran (approval code: IR.TUMS.SPH.REC.1396.3228).

Funding Support: This study was financially supported by the Faculty of Health of Tehran University of Medical Sciences, Tehran, Iran.

References

1. Torabi SA, Shokri I, Tofighi S, Heydari J. Integrated relief pre-positioning and procurement planning in humanitarian supply chains. *Transport Res E Logist Transport Rev*. 2018;**113**:123–46. doi: 10.1016/j.tre.2018.03.012.

2. Apta A. Foundation trends and technology, information operation management. *Humanitarian logistics: A new field of research and action*. Now Foundations and Trends; 2009. p. 1–100. doi: 10.1561/0200000014.
3. Bai X, Gao J, Liu Y. Prepositioning emergency supplies under uncertainty: A parametric optimization method. *Eng Optim*. 2017;**50**(7):1114–33. doi: 10.1080/0305215x.2017.1328508.
4. Rawls CG, Turnquist MA. Pre-positioning of emergency supplies for disaster response. *Transport Res Part B Methodol*. 2010;**44**(4):521–34. doi: 10.1016/j.trb.2009.08.003.
5. Duran S, Gutierrez MA, Keskinocak P. Pre-positioning of emergency items for CARE international. *Interfaces*. 2011;**41**(3):223–37. doi: 10.1287/inte.1100.0526.
6. Renkli C, Duran S. Pre-positioning disaster response facilities and relief items. *Hum Ecol Risk Assess*. 2015;**21**(5):1169–85. doi: 10.1080/10807039.2014.957940.
7. Thomas AS, Kopczak LR. *From logistics to supply chain management: The path forward in the humanitarian sector*. Fritz Institute; 2005. 14 p.
8. Opit PF, Nakade K. Emergency response model of stock-prepositioning with transportation constraints. *2015 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)*. 2015. p. 239–43.
9. Madu NC, Kuei CH. Disaster relief supply chain quality management (DRSCQM). *Int J Qual Reliab Manag*. 2015;**31**(9):1052–67. doi: 10.1108/ijqrm-08-2013-0136.
10. Beamon BM, Kotleba SA. Inventory management support systems for emergency humanitarian relief operations in South Sudan. *Int J Logist Manag*. 2006;**17**(2):187–212. doi: 10.1108/09574090610689952.
11. Caunhye AM, Nie X, Pokharel S. Optimization models in emergency logistics: A literature review. *Soc Econ Plann Sci*. 2012;**46**(1):4–13. doi: 10.1016/j.seps.2011.04.004.
12. Ergun O, Karakus G, Keskinocak P, Swann J, Villareal M. Overview of supply chains for humanitarian logistics. *Models and algorithms for optimization in logistics*. Dagstuhl, Germany: Schloss Dagstuhl; 2009.
13. Bozkurt M. *The effects of natural disaster trends on the pre-positioning implementation in humanitarian logistics networks [dissertation]*. Ankara: METU; 2011.
14. Carroll A, Tatham PH, Neu J. Volatility, unpredictability and asymmetry: An organising framework for humanitarian logistics operations? *Manag Res News*. 2009;**32**(11):1024–37. doi: 10.1108/01409170910998264.
15. Mochizuki J, Toyasaki F, Sigala IF. Toward resilient humanitarian cooperation: Examining the performance of horizontal cooperation among humanitarian organizations using an agent-based modeling (ABM) approach. *J Nat Disast Sci*. 2015;**36**(2):35–52. doi: 10.2328/jnds.36.35.
16. Gutjahr WJ, Nolz PC. Multicriteria optimization in humanitarian aid. *Eur J Oper Res*. 2016;**252**(2):351–66. doi: 10.1016/j.ejor.2015.12.035.
17. Balcik B, Bozkir CDC, Kundakcioglu OE. A literature review on inventory management in humanitarian supply chains. *Surv Oper Res Manag Sci*. 2017;**21**(2):101–16. doi: 10.1016/j.sorms.2016.10.002.
18. Moher D, Liberati A, Tetzlaff J, Altman DG, Prisma Group. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Med*. 2009;**6**(7). e1000097. doi: 10.1371/journal.pmed.1000097. [PubMed: 19621072]. [PubMed Central: PMC2707599].
19. *Critical appraisal skills programme (CASP)*. 2018. Available from: https://casp-uk.net/casp-tools-checklists/Access.
20. Farahani R, Rezapour S. *Logistics operations and management: Concepts and models*. Elsevier; 2011.
21. Balcik B, Beamon BM. Facility location in humanitarian relief. *Int J Logist Res Appl*. 2008;**11**(2):101–21. doi: 10.1080/13675560701561789.
22. Oloruntoba R, Gray R. Humanitarian aid: An agile supply chain? *Supply Chain Manag*. 2006;**11**(2):115–20. doi: 10.1108/13598540610652492.
23. Akgun I, Gumusbuga F, Tansel B. Risk based facility location by using fault tree analysis in disaster management. *Omega*. 2015;**52**:168–79. doi: 10.1016/j.omega.2014.04.003.
24. Alem D, Clark A, Moreno A. Stochastic network models for logistics planning in disaster relief. *Eur J Oper Res*. 2016;**255**(1):187–206. doi: 10.1016/j.ejor.2016.04.041.
25. Babaei A, Shahanaghi K. A novel algorithm for identifying and analyzing humanitarian relief logistics problems: Studying uncertainty on the basis of interaction with the decision maker. *Process Integrat Optim Sustain*. 2018;**2**(1):27–45. doi: 10.1007/s41660-017-0029-7.
26. Campbell AM, Jones PC. Prepositioning supplies in preparation for disasters. *Eur J Oper Res*. 2011;**209**(2):156–65. doi: 10.1016/j.ejor.2010.08.029.
27. Davis LB, Samanlioglu F, Qu X, Root S. Inventory planning and coordination in disaster relief efforts. *Int J Prod Econ*. 2013;**141**(2):561–73. doi: 10.1016/j.ijpe.2012.09.012.
28. Galindo G, Batta R. Prepositioning of supplies in preparation for a hurricane under potential destruction of prepositioned supplies. *Soc Econ Plann Sci*. 2013;**47**(1):20–37. doi: 10.1016/j.seps.2012.11.002.
29. Charles A, Lauras M, Van Wassenhove LN, Dupont L. Designing an efficient humanitarian supply network. *J Oper Manag*. 2016;**47-48**(1):58–70. doi: 10.1016/j.jom.2016.05.012.
30. Richardson D, de Leeuw S, Vis IFA. Conceptualising inventory prepositioning in the humanitarian sector. *Collaborative networks for a sustainable world*. Springer; 2010. p. 149–56. doi: 10.1007/978-3-642-15961-9_17.
31. John L, Ramesh A, Sridharan R. Humanitarian supply chain management: A critical review. *Int J Serv Oper Manag*. 2012;**13**(4):498. doi: 10.1504/ijsom.2012.050143.
32. Van Wassenhove LN, Pedraza Martinez AJ. Using OR to adapt supply chain management best practices to humanitarian logistics. *Int Trans Oper Res*. 2012;**19**(1-2):307–22. doi: 10.1111/j.1475-3995.2011.00792.x.
33. Leeuw S, Vis IFA, Jonkman SN. Exploring logistics aspects of flood emergency measures. *J Conting Crisis Manag*. 2012;**20**(3):166–79. doi: 10.1111/j.1468-5973.2012.00667.x.
34. Kunz N, Reiner G. A meta-analysis of humanitarian logistics research. *J Hum Logistics Supply Chain Manag*. 2012;**2**(2):116–47. doi: 10.1108/20426741211260723.
35. Tatham P, Spens K, Kovacs G. The humanitarian common logistic operating picture: A solution to the inter-agency coordination challenge. *Disasters*. 2017;**41**(1):77–100. doi: 10.1111/disa.12193. [PubMed: 26987936].
36. Maghfiroh MFN, Hanaoka S. Last mile distribution in humanitarian logistics under stochastic and dynamic consideration. *2017 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)*. 2017. p. 1411–5.
37. Biswal AK, Jenamani M, Kumar SK. Warehouse efficiency improvement using RFID in a humanitarian supply chain: Implications for Indian food security system. *Transport Res E Logist Transport Rev*. 2018;**109**:205–24. doi: 10.1016/j.tre.2017.11.010.
38. Jahre M, Pazirandeh A, Van Wassenhove LN. Defining logistics preparedness: A framework and research agenda. *J Hum Logistics Supply Chain Manag*. 2016;**6**(3):372–98. doi: 10.1108/jhlscm-04-2016-0012.
39. Roh SY, Jang HM, Han CH. Warehouse location decision factors in humanitarian relief logistics. *Asian J Ship Logist*. 2013;**29**(1):103–20. doi: 10.1016/j.ajsl.2013.05.006.
40. Boonmee C, Arimura M, Asada T. Facility location optimization model for emergency humanitarian logistics. *Int J Disast Risk Reduc*. 2017;**24**:485–98. doi: 10.1016/j.ijdrr.2017.01.017.
41. Kovacs G, Glenn Richey R, Spens K. Identifying challenges in humanitarian logistics. *Int J Phys Distrib Logist Manag*. 2009;**39**(6):506–28. doi: 10.1108/09600030910985848.

Table 1. The Characteristics of the Studies Included in the "Factors Affecting the Prepositioning of Relief Items"

Reference No.	First Author (Year)	Country	Design	Population/Sample	Main Results
(21)	Balcik (2008)	Global	Literature review and mathematical model development	N/A	Pre- and post-disaster investments have significant effects on relief operation.
(22)	Oloruntoba (2006)	Global	Development of a model of agile supply chain for humanitarian aid	N/A	Planning has a significant role in humanitarian supply chain. One of the goals of PRI is to place relief items close to potential disaster areas.
(1)	Torabi (2018)	Global	Literature review	N/A	Scenario-based models help researchers reduce uncertainties related to time, cost, transportation capacity, damage level, and demand level.
(2)	Apte (2010)	Pakistan and Indonesia	Survey case studies to learn from the past experience and review analytical models	Pakistan, Indonesia and USA (A monograph)	Relief items should be prepositioned in the best possible place. Logistics managers should consider many factors related to supply change including contingency models for warehouse site selection, demand prediction to estimate the number of relief items for prepositioning, and determining distribution canals.
(23)	Akgün (2014)	Global	Development of an optimization model	The cities (demand points and candidate facility locations) in Turkey	Explicit consideration of risk can create significant differences in risk levels.
(24)	Alem (2016)	Brazil	Stochastic network models	The floods and landslides in Rio de Janeiro state, Brazil	Uncertainty is a critical challenge that should be resolved. It is difficult to predict the level of demand for relief item during disasters. Uncertainty is modeled through two-stage scenario-based accidental planning.
(25)	Babaei (2018)	Global	Comprehensive novel algorithm	N/A	The recommended algorithm is appropriate for identifying and analyzing humanitarian relief logistics problems.
(10)	Beamon (2006)	South Sudan	Quantitative modeling, simulation, and statistics	The complex emergency in south Sudan	Warehousing operations are often complicated by a high level of staff turnover, a large number of volunteer participants, and inadequacy of financial resources. A mathematical model is more flexible than other methods.
(26)	Campbell (2011)	Global	Sensitivity analysis	The bottom of the grid can be thought of as points along the Gulf of Mexico during hurricane season	If the supply point is located closer to the disaster, it can offer faster delivery of supplies after the disaster which is desirable.
(27)	Davis (2013)	Global	Model development	N/A	The model presented in this paper incorporates forecasted hurricane path and intensity to determine how best to preposition supplies in an established single commodity supply network where one or more of the nodes is in a high-risk path for a particular event. This situation could arise either when strategic prepositioning decisions have been made, or when an existing network is already used to service the community.
(28)	Galindo (2013)	Global	Model development	N/A	This paper focuses on preparedness activities in a hurricane. A main part of the preparedness activities relates to the preposition of emergency supplies. One of the main advantages of prepositioning is the reduce response time and improve response time, it is desirable to preposition the emergency supplies near to the demand points (DPs).
(29)	Charles (2017)	Global	Stochastic optimization	N/A	The main result is that a one-stage network, with regional warehouses, provides the most efficient response and is capable of satisfying demand. A two-stage network where the goods first pass through the first-stage regional warehouses, costs more than a centralized network. Decentralizing more by adding the second stage local warehouses at country levels is not justified.

(17)	Balcik (2017)	Global	Literature Review	13 organizations that are active in disaster relief	This article provides an in-depth review and analysis of analytical approaches developed for humanitarian inventory management. Although there is a well-established inventory management literature addressing the basic inventory questions (when/where/how much to store) within commercial supply chain settings, the existing models and policies cannot be directly applied to manage humanitarian inventories.
(5)	Duran (2011)	Global	Model development	CARE International	The results of our study illustrate how to best use up-front investment to achieve the largest possible response-time benefit and also support the implementation of a gradual network expansion strategy. The model estimates the frequency, location, and magnitude of potential demand based on historical data.
(30)	Richardson (2010)	Global	Literature review	N/A	The factors that affect these decisions were identified and discussed in section three, emphasizing the potential to collaborate as impacting on many of the other factors which affect IPP decisions.
(31)	John (2012)	Global	Critical review	N/A	This paper presents a review of the major publications in the HSCM area along with some relevant publications from the allied fields of supply chain for a clear understanding of the concepts and to draw parallels from the CSCM.
(9)	Madu (2015)	Global	A structured approach to making decisions	N/A	In this paper, disaster relief life cycle is analyzed in the context of CIMO logic and LSS principles. The systemic and holistic procedure developed here views the environment of disaster relief as dynamic, complex, chaotic, and ever-changing and takes into account the fact that relief organizations' actions often involve a team of diverse specialists working on a project basis.
(15)	Mochizuki (2015)	Global	A multi-agent simulation model	UN Humanitarian Response Depot (UNHRD) system	A stylized model of one service provider, a two-member organization, and multiple humanitarian crises was developed to evaluate four sourcing options, namely: (i) own storage, (ii) UN storage for own items, (iii) stock-swap, and (iv) white stock uses under two budgeting regimes of fixed and flexible constraints.
(14)	Carroll (2009)	Global	Examines collaborative supply chain management (CSCM)	N/A	The application of commercial and supply chain derivations from lean and agile concepts will, short term, offer efficiencies in the design of HLSCM systems and structures. In the long term, the solution for HLSCM effectiveness and the ability to deal efficiently with unpredictability lies, particularly (and it could be argued, solely), within the HLSCM sector itself.
(11)	Caunhye (2012)	Global	A literature review	N/A	This paper reviews optimization models used in the field of emergency logistics. The main activities are broken down into pre disaster operations (consisting mainly of facility location stock pre-positioning and evacuation) and post-disaster operations (involving relief distribution and casualty transportation).
(16)	Gutjahr (2016)	Global	A bi-objective, bi-level optimization model	N/A	The optimization of the location of capacitated distribution centers between which individual persons can choose requires adequate modeling of the individuals' behavior.
(8)	Opit (2015)	Global	Develop a stock pre-positioning model	Apply this model to Indonesia with 34 disaster areas and 16 temporary distribution centers	This paper proposed a new stock-prepositioning model that simultaneously generates the maximum proportion of relief demand covered in distribution centers and the maximum amount of relief demand distributed to a single disaster area within a certain period of time.