



## LJMU Research Online

**Shahgholian, A, Kumar, P and Singh, RK**

**Learnings from COVID-19 for Managing Humanitarian Supply Chains:  
Systematic Literature Review and Future Research Directions**

<http://researchonline.ljmu.ac.uk/id/eprint/15851/>

### Article

**Citation** (please note it is advisable to refer to the publisher's version if you intend to cite from this work)

**Shahgholian, A, Kumar, P and Singh, RK Learnings from COVID-19 for Managing Humanitarian Supply Chains: Systematic Literature Review and Future Research Directions. Annals of Operations Research. ISSN 0254-5330 (Accepted)**

LJMU has developed **LJMU Research Online** for users to access the research output of the University more effectively. Copyright © and Moral Rights for the papers on this site are retained by the individual authors and/or other copyright owners. Users may download and/or print one copy of any article(s) in LJMU Research Online to facilitate their private study or for non-commercial research. You may not engage in further distribution of the material or use it for any profit-making activities or any commercial gain.

The version presented here may differ from the published version or from the version of the record. Please see the repository URL above for details on accessing the published version and note that access may require a subscription.

For more information please contact [researchonline@ljmu.ac.uk](mailto:researchonline@ljmu.ac.uk)

<http://researchonline.ljmu.ac.uk/>

[Click here to view linked References](#)

# **Learnings from COVID-19 for Managing Humanitarian Supply Chains: Systematic Literature Review and Future Research Directions**

**Pravin Kumar<sup>1</sup>, Rajesh Kumar Singh<sup>2</sup>, and Azar Shahgholian<sup>3</sup>**

1. Department of Mechanical Engineering, Delhi Technological University, Delhi, INDIA
2. Management Development Institute, Gurgaon, Haryana, INDIA
3. Liverpool Business School, Liverpool John Moores University, UK

[<sup>2</sup>Email-rksdce@yahoo.com](mailto:Email-rksdce@yahoo.com) (Corresponding Author)

## **Abstract**

The COVID-19 pandemic has been experienced as the most significant global disaster after the Spanish flu in 1918. Millions of people lost their life due to a lack of preparedness and ineffective strategies for managing humanitarian supply chains (HSC). Based on the learnings from this pandemic outbreak, different strategies for managing the effective HSC have been explored in the present context of pandemics through a systematic literature review. The findings highlight some of the major challenges faced during the COVID-19 pandemic, such as lack of planning and preparedness, extended shortages of essential lifesaving items, inadequate lab capacity, lack of transparency and visibility, inefficient distribution network, high response time, dependencies on single sourcing for the medical equipment and medicines, lack of the right information on time, and lack of awareness about the protocol for the treatment of the viral disease. Some of the significant learnings observed from this analysis are the use of multiple sourcing of essential items, joint procurement, improving collaboration among all stakeholders, applications of IoT and blockchain technologies for improving tracking and traceability of essential commodities, application of data analytics tools for accurate prediction of next possible COVID wave/disruptions and optimization of distribution network. Limited studies are focused on finding solutions to these problems in managing HSC. Therefore, as a future scope, researchers could find solutions to optimizing the distribution network in context to pandemics, improving tracing and tracking of items during sudden demand, improving trust and collaborations among different agencies involved in HSC.

**Keywords:** COVID-19, Humanitarian supply chains, Poverty and Food Security, Swift Trust, Propositioning, Coordination, Collaboration, Systematic literature review.

## 1. Introduction

The COVID-19 pandemic has caused many disruptions in business and society. It may be considered as the most severe pandemics of this century. Pandemics differ from other disasters in complicity, information needs and types, the pace of change and impact, and impact for an extended period (Thompson and Anderson, 2021). Pandemics may result in social and economic disruption due to sudden illness and mortality. In general, humanitarian logistics and supply chain management (HLSCM) mainly focus on lifesaving operations after a natural disaster (Kunz and Reiner, 2012). Sokat and Atlay (2021) have highlighted the uniqueness of the vulnerable groups and conducted a literature review to identify the research needs in HLSCM. They observed that no literature is available within the HLSCM that focuses on the uniqueness of the vulnerable groups, risk factors, and the way to mitigate them. The vulnerable people are at high risk of this pandemic, as they do not have proper access to healthcare and social services. Till August 30, 2021, the outbreak of COVID-19 has affected 221 countries of the world and caused the death of millions of the people (Worldometers, 2021). It has a global impact on most countries' socio-economic conditions due to the lockdown, social distancing, logistics disruption, export-import disruption, and supply and distribution uncertainties. The outbreak of COVID-19 poses a significant challenge for the humanitarian organization to address the various issues related to the relief operations.

The severity of different pandemics depends on their novelty and uniqueness. Various strains of the coronavirus have been found across the world. COVID-19 is the seventh identified coronavirus infecting humans' respiratory tract and lungs in the last two decades (Burki, 2020). The fungal infection of the sinuses is challenging to treat and is often fatal (BMJ, 2021). Yet, COVID-19 is not fully understood, and some precautions such as social distancing, lockdowns, stay-at-home, use of mask and sanitizer have been prescribed. However, many vaccines are in use, but the effectiveness of the vaccinations is not yet evident. The different companies claim effectiveness as per their experimentation and observation.

Including health and medical issues, COVID-19 has restricted many business and personal activities of the people such as tourism, education, export-import, production, social gathering, movement, etc. The changing demand pattern has affected demand forecasting, manufacturing and supply lead time, inventory management, sourcing strategies, etc. Karuppiyah et al. (2021) reviewed the impact of COVID-19 on health, economic, social, and industrial activities. They

1 identified twenty critical challenges in sustainable humanitarian supply chain management.  
2 The analysis found the five most significant challenges: problem in facility location, short lead  
3 time for emergency supply, the spread of rumours, the rapid emergence of new clusters, and  
4 doubt concerned with the available remedies. They recommended public-private partnership  
5 as the best strategy to meet these challenges.  
6  
7

8  
9 Malmir and Zobel (2021) proposed a mathematical model for minimizing the total cost of  
10 delivering humanitarian aids for the pandemic relief, focusing on sustainable operations, total  
11 transportation and delivery costs, and equity and deprivation costs. They covered the social  
12 costs in their model in terms of deprivation and equity cost so that a manager could respond to  
13 the pandemic outbreaks in the best possible ways. Farooq et al. (2021) proposed a framework  
14 emphasizing the integration of Industry 4.0 technologies, resilience strategies, and  
15 sustainability to overcome the impact of the pandemic. Based on the exploration of the possible  
16 contribution of HSC in reducing the impact of COVID-19, the following research question is  
17 proposed.  
18  
19

20  
21  
22 ***RQ1:** How does the HSC address the issues related to pandemic outbreak of COVID-19 to*  
23 *reduce the suffering of the people and fulfill their needs.*  
24  
25

26  
27 The ripple effect of COVID-19 has spread across the industry. It has a cascading effect  
28 extending through various sectors in a supply chain. The supply of essential items was utterly  
29 disrupted due to lockdown and worldwide restrictions on the free flow of goods and services  
30 (Ivanov, 2020a). Due to restrictions on export and import, businesses had to put the flow of  
31 raw material on hold, which led to a huge shortage of supply of the goods and increased the  
32 cost (Dolguet al., 2020). On the other hand, sales were dramatically reduced due to decreased  
33 demand for many perishable items and uneven distribution (Magzter, 2020). Also, it led to the  
34 wastage of these items. The occurrence of the COVID-19 pandemic has exposed challenges of  
35 the humanitarian supply chain due to shortage and disruption of supplies of essential items such  
36 as PPEs (personal protective equipment), testing kits, ventilators, hospital beds, oxygen  
37 cylinders, and vaccines. A chaotic situation was observed due to poor communication,  
38 contradictory and insufficient information, confusion among first responders and citizens, and  
39 lack of resources. These issues led to slow relief, resulting in prolonged suffering and increased  
40 deaths. HSCs (Humanitarian Supply Chains) mainly focus on saving lives while responding to  
41 disasters and emergencies and are characterized by turbulence, uncertainties, and complex  
42 dynamic environments (Day et al., 2012; Van Wassenhove, 2006). Based on the difficulties in  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65

managing the HSC during the peak time of COVID-19, the following research question is proposed.

***RQ2:** What are the main challenges in managing HSC during the COVID-19 pandemic.*

Due to restrictions on movement, over control/restriction on travel, shortages in labor and materials, COVID-19 became a serious threat to the life of human beings (Kumar and Singh, 2021a). Unlike SARS or even Ebola, the COVID-19 has disrupted global supply chains as well as humanitarian supply chains. Some of the main challenges influencing the performance of humanitarian supply chains are the poor resource infrastructure, high dependency on donor funding, demand uncertainty, and lack of resources (Kovacs & Spens, 2007; Balcik & Beamon, 2008; Gatignon et al., 2010). Limited research has been done on using insights emerging from COVID 19 for managing HSC. Thus, it is an opportunity to learn new scenarios emerging after the COVID-19 outbreak. Therefore, we are also trying to answer the following research question in our study.

***RQ3:** What are the learnings from COVID-19 for future research directions in context to HSC.*

The recent episode of pandemic outbreak has increased the global burden on humanitarian efforts. The increasing role of HSC may be observed in the outbreaks of epidemics such as SARS (2002-03), Swine Flu-H1N1 virus (2009-10), Ebola (2015-16), MERS (2015-16), and now COVID-19 (2019 to present). In this paper, a systematic literature review (SLR) is used to make the required observations and determine future research directions. It has a long tradition to summarize the results of existing research and propose the hypothesis. The SLR has been recently used successfully in the HSCs context (Marić et al., 2021; Queiroz et al., 2020, Dubey et al., 2015).

The organization of the paper is as follows: Section 2 highlights the research methodology, Section 3 represents the findings and content analysis of the literature, Section 4 deals with learnings from COVID-19, Section 5 elaborates the research gaps and directions for future research. Section 5 concludes the research. This study will contribute to identifying new challenges during the pandemic and possible strategies for managing HSC during such uncertain times.

## 2. Research methodology

As a first step, the scope of the study considering the interdisciplinary approach is defined. Before exploring the literature on the research articles on the issues related to the pandemic outbreak, we used a grounded theory approach to understand participants' observation toward COVID-19 and its impact. Grounded theory is based on the approach of naturalistic inquiry and inductive data analysis. Grounded theory discovers new theoretical insights and innovations avoiding the traditional logical deductive reasoning (Connell and Lowe, 1997); and it is considered to be "emergent explicit" (Martin and Woodside, 2008).

According to Nunkoo and Ramkissoon (2016), the sampling process in grounded theory research is based on concepts, properties, dimensions, and characteristics, not on the samples of specific groups and units of time. Due to lockdown and imposition of social distancing, it could not be possible to conduct face-to-face interviews of the participants, logisticians, and sufferers of COVID-19. Online interviews were conducted to know the opinion and observation of the people regarding the humanitarian issues. Interviews were conducted with 12 participants. Out of 12 participants, five experts were working as volunteers in humanitarian supply chains, four experts had suffered from COVID-19. They were cured after treatment, and three experts were working as medical practitioners. Many open-ended questions were asked from the experts, which are not generally found in the research article. Some important component of the research questions are the attitude and motivation of the medical practitioners to help the COVID-19 patients, unavailability of beds in hospitals, unavailability of medicines, lack of oxygen supply, shortage of ventilators, the effectiveness of home quarantine and telemedicine, unavailability of vaccines, food supply, etc. In addition, we also consulted many news articles, news channels, social media, etc.

The concept of the humanitarian supply chain and its application in epidemic/pandemic outbreaks have become more important for the last two decades. Its development is closely integrated with the development of supply chain management. Earlier, it was simply managed as disaster/relief management without using the Humanitarian supply chain or humanitarian logistics management concepts. In recent years, the outbreak of COVID-19 has been considered one of the most dangerous infectious diseases, which has led to the death of more than 4.51 million people worldwide, as shown in Table 1.

**Table 1: Some major epidemics/pandemics across the world**

| Years/Duration | Name of the Epidemics/pandemics | Causes              | Death (Approx) | Region                     | References                |
|----------------|---------------------------------|---------------------|----------------|----------------------------|---------------------------|
| 2019-present   | COVID-19                        | Coronavirus         | 4.51 M         | Worldwide                  | Worldometers (2021)       |
| 1981-present   | HIV/AIDS                        | Virus / Chimpanzees | 25-35M         | Worldwide                  | Pandey and Galvani (2019) |
| 1968-1969      | Hong Kong Flu                   | Influenza A/H3N2    | 1-4 M          | Worldwide                  | Akin and Gözel (2020)     |
| 1918-1920      | Spanish flu                     | Influenza A/H1N1    | 40-50M         | Worldwide                  | Antonovics et al. (2006)  |
| 1519–1520      | Mexico smallpox                 | Smallpox            | 5–8 million    | Mexico                     | Acuña-Soto et al. (2002)  |
| 1346-1353      | Black Death                     | Bubonic plague      | 75-200 M       | Europ, Asia, North America | DeWitte (2014)            |
| 541-549        | Plague of Justinian             | Influenza A/H1N1    | 15-100 M       | Europe and West Asia       | Mordechai et al. (2019)   |
| 165-180        | Antonine Plague                 | Smallpox or measles | 5-10 M         | Roman Empire               | Yapijakis (2009)          |

For the systematic literature review, we have used the concepts of the grounded theory proposed by Wolfswinke et al. (2013). The entire literature review is divided into the following five steps.

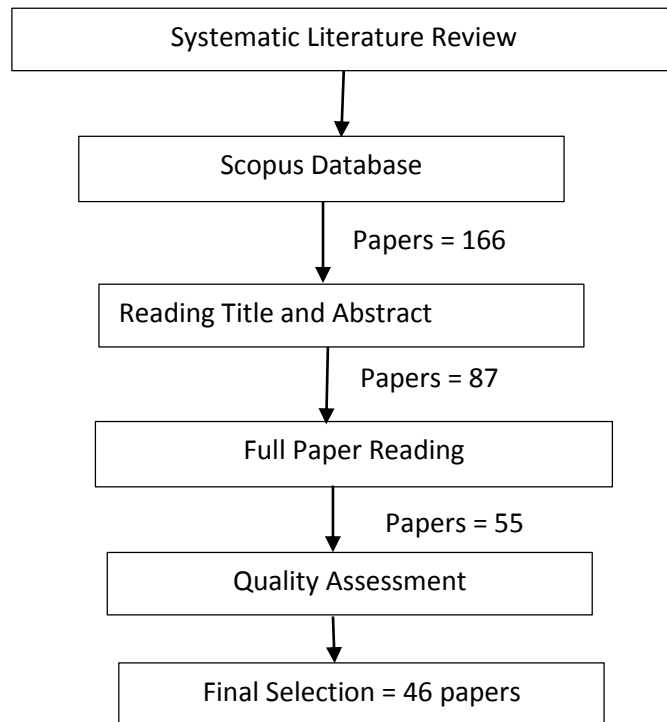
- *Planning*: Grounded theory and literature review were planned to connect the humanitarian issues with the impact of COVID-19.
- *Identifying*: Some keywords such as an epidemic, pandemic, coronavirus, COVID-19, humanitarian supply chains, and humanitarian logistics were searched on the Scopus database.
- *Evaluating*: The research articles were sorted based on abstract reading and then final full paper readings.
- *Collecting/combining* – From these research articles sorted out from the literature is used to find out the challenges faced in Humanitarian supply chains during the outbreaks of COVID-19, and some significant learnings are outlined.

- *Explaining and Summarizing*: Some major research gaps are identified, and directions of future research are proposed.

For ensuring the objectivity and reliability of the entire process, a research protocol is developed, as shown in Table 2 (Queiroz et al., 2020). In the second stage, based on the research protocol, many research articles were identified. Only those journals are retained that are indexed by Scopus. The conference papers are not included in this study. Both conceptual and empirical types of papers from the journals are considered in this literature review. Moreover, to extract data and explore the papers, the *POP (Publish or Perish)* software (De Rond and Miller, 2005) and *VOSviewer* (Yu et al., 2020) for network analysis are used. At a third stage, the main findings from the analysis of papers are reported. Using the systematic literature review (SLR) methodology, several insights are unveiled into the knowledge literature. Figure 1 highlights the main schematic flow diagram of the review process. Finally, we have shortlisted forty-six research papers for this SLR. Detail of these research papers is also given in Appendix A. As this SLR is in context to current Covid 19 problem, we have also referred some news articles and reports as given in Appendix B.

**Table 2: Research protocol for literature review**

| S. No. | Research Protocol  | Detailed description  |
|--------|--|---|
| 1.     | Research database:   | Scopus database   |
| 2.     | Publication type:  | Peer-reviewed journals (Scopus Indexed)   |
| 3.     | Language:  | English   |
| 4.     | Date Range:  | January 2012- March 12, 2021  |
| 5.     | Search filed:  | Titles, abstracts, and keywords.  |
| 6.     | Search terms applied in Titles in Scopus database and titles, abstract, and keywords in POP: | “epidemic” OR “pandemic” OR “COVID 19” or “coronavirus” AND “humanitarian supply chains”. |
| 7.     | Criteria for inclusion:  | Papers that presented some outbreaks in a humanitarian context.                           |
| 8.     | Criteria for exclusion:  | Papers that presented some outbreak discussion purely without humanitarian concern.       |
| 9.     | Data and network analysis:   | Used VOSviewer software   |



**Figure 1: Research protocol for SLR**

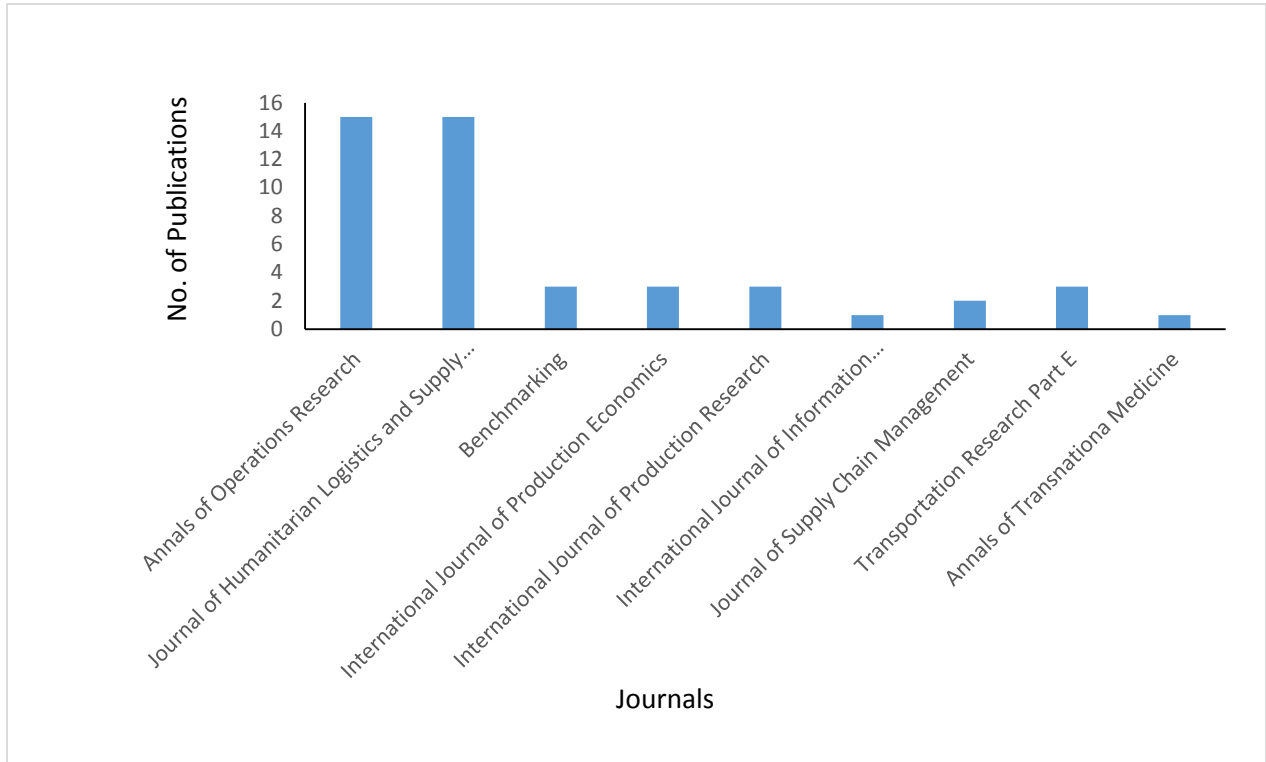
### 3. Research findings and analysis

Research findings have been analyzed in two parts. The first part deals with descriptive analysis, and the second part deals with theoretical analysis.

#### 3.1 Descriptive analysis

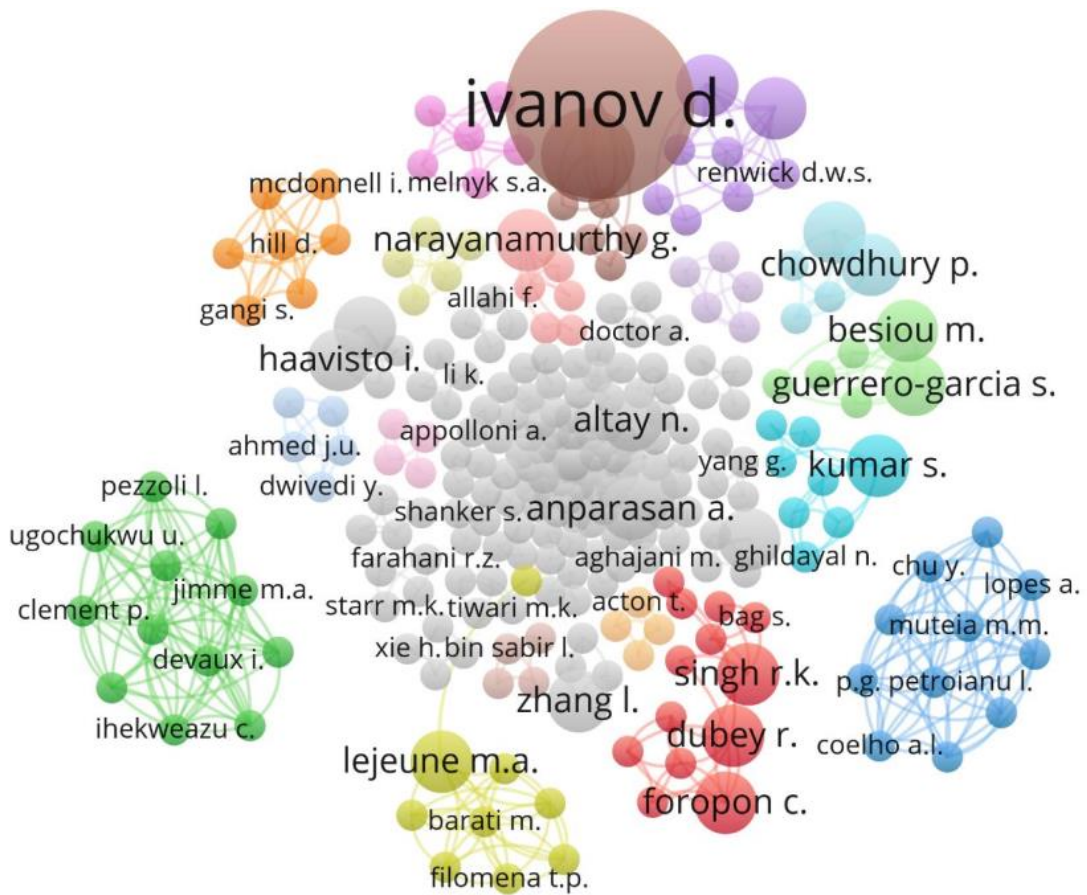
In this section, we are trying to do a descriptive analysis of papers published in different journals in area of study. Figure 2 shows the number of research articles published in each journal. It is observed that Annals of Operations Research (ANOR) has published the highest number of research papers. Apart from ANOR, the Journal of Humanitarian Logistics and Supply Chain Management (JHLSCM) also represents most publications in this domain. Other journals publishing articles related to the pandemic and humanitarian supply chains are Benchmarking: An International Journal, International Journal of Production Economics, International Journal of Production Research, International Journal of Information Management, Journal of Supply Chain Management, and Transportation Research Part E. Although, many journals have published articles related to pandemics, but their focus is entirely different from humanitarian issues. Some journal focuses on medicines and others on

1 operations and supply chains and some other issues. Therefore, we have mainly considered  
2 publications related to pandemics.  
3  
4

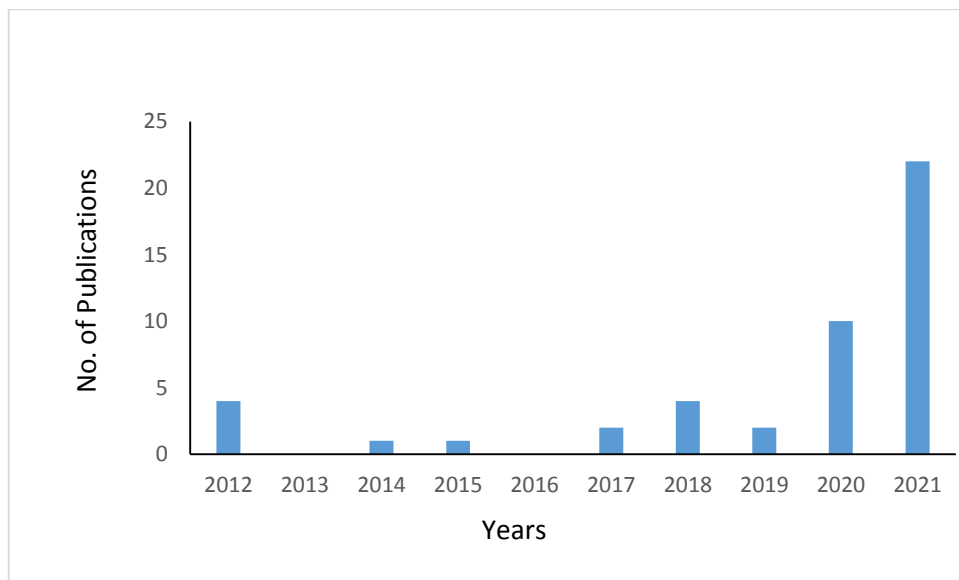


27  
28  
29  
30  
31 **Figure 2: Publications by journals**

32  
33 Figure 3 shows the network visualization of authors and co-authors. Humanitarian Supply  
34 Chain Management is a relatively new area of research. Very few authors have contributed  
35 to the research in this area. It can be observed that most of the publications related to the  
36 humanitarian issues in pandemics have been published within two years (2020-21). Figure  
37 4 shows the year-wise publication of the articles related to Humanitarian supply chains and  
38 pandemics.  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65

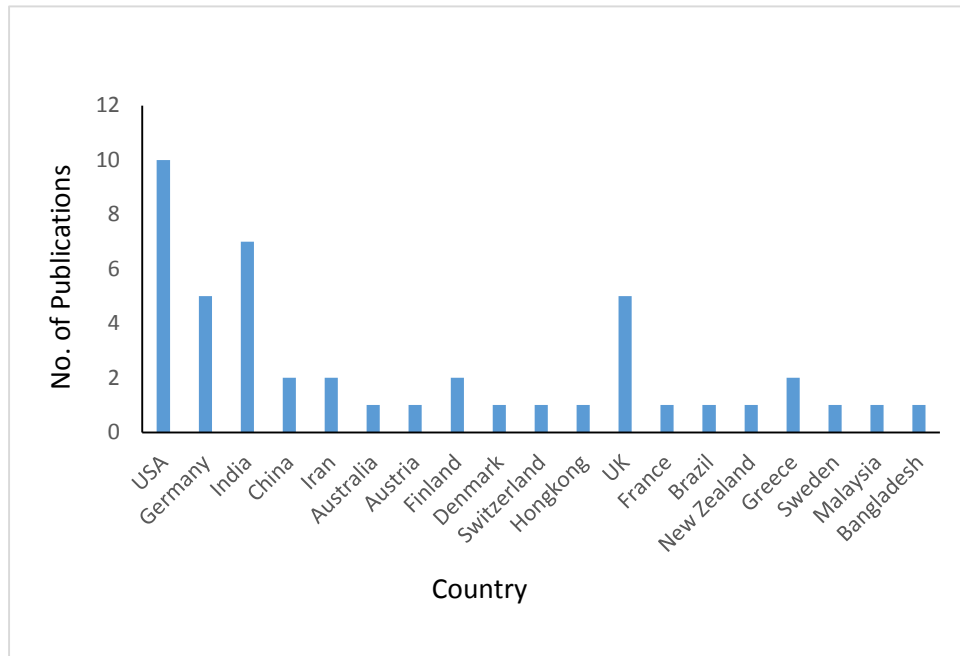


**Figure 3: Network Visualization of Authors and Co-authors.**



**Figure 4: Year-wise Publications**

1 Similarly, if the publications are analyzed in terms of countries, the US is first in this  
 2 dimension, followed by the United Kingdom and India, as shown in Figure 5. Other leading  
 3 countries publishing the articles on HLSCM and Pandemics are Germany, France, China,  
 4 Australia, Brazil, Italy, Iran, and Norway.  
 5  
 6  
 7



8  
 9  
 10  
 11  
 12  
 13  
 14  
 15  
 16  
 17  
 18  
 19  
 20  
 21  
 22  
 23  
 24  
 25  
 26  
 27  
 28  
 29  
 30  
 31  
 32 **Figure 5: Publications by different countries**

33  
 34 Figure 6 shows keyword dynamics. These are acquired from the titles of references from  
 35 our dataset of 46 papers considered for review. In this word treemap, the size of circles  
 36 shows the frequency of keywords, and the color indicates the relationship between them.  
 37 The role of word segments such as "COVID-19," "humanitarian logistics," "supply chain,"  
 38 "disaster management," "supply chain management," and "humanitarian supply chains" is  
 39 reasonably identifiable. In the other smaller sizes of circles, various other related words  
 40 such as "ripple effect," "sustainability," "collaboration," and "countermeasure" are shown.  
 41  
 42  
 43  
 44  
 45  
 46

47  
 48 There is a trend to use Coronavirus and COVID-19 interchangeably, but we can also notice  
 49 the growth of other interesting topics related to "Coronavirus and COVID-19", such as  
 50 "emergency response," "disaster communication," "causalities," and "collaborative  
 51 forecasting." In the other smaller size circles, we have many related terms. Taking into  
 52 account the word dynamics, we observe, "COVID 19" and "Humanitarian Logistics" are  
 53 well-explored topics due to their variations (e.g., disaster management, emergency  
 54 response, risks, countermeasures, etc.).  
 55  
 56  
 57  
 58  
 59  
 60  
 61  
 62  
 63  
 64  
 65



1 (Lancet, 2020). They missed a strategic plan for the pandemic response ready to be adapted  
2 and implemented against the threat of COVID-19. There is the need to establish a proper  
3 national preparedness plan even if the next pandemic may not appear for some years. The lack  
4 of a national response strategy led a mass confusion among the responders at the federal, state,  
5 and local levels of different governments. The Centres for Disease Control and hospitals did  
6 not anticipate the nature of the virus and so could not respond adequately.  
7  
8  
9

10  
11 **(ii) Extended shortages:** During the first wave of COVID 19, all hospitals and health centers  
12 were facing a shortage of various medical equipment such as N95 masks and PPE Kits, among  
13 others. Even after one year of the COVID outbreak, i.e., during the second wave of COVID-  
14 19 in India, the hospitals were facing a shortage of oxygen supply, beds, ventilators, and  
15 vaccines. Many other countries were also facing similar problems but not so acute. Even in the  
16 developed countries like the US, the Department of Health and Human Services resonated with  
17 the urgent calls from hospitals for more PPEs, as they expected their stocks' depletion as cases  
18 continued to increase (HHS, 2020). Delay of 3-6 months for N95 masks was reported, and  
19 supply was insufficient per demand (CBS News, 2020a, b). Due to high demand and less  
20 production of vaccines and stage-wise supply of the vaccines for a different category of the  
21 people, the distribution of the vaccines becomes very difficult and results in a shortage of  
22 supply.  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32

33  
34 **(iii) Inadequate lab capacity:** In March 2020, India had only 14 RT-PCR testing labs, and by  
35 the end of the month, 106 Virus Research & Diagnostic Laboratories (VRDLs) were added. By  
36 July 2020, India had 1,600 RT-PCR labs. The number of daily tests shot up from 1,500 in April  
37 to 200,000 in June and 1 million in October 2020. The first wave of COVID-19 subsided in  
38 November; at that time, India had only 2,257 COVID-19 testing labs. The average waiting time  
39 for getting test results was 12-24 hours. However, from December 2020 to May 2021, only 249  
40 new COVID-19 testing labs were added. With the alarming spread of the virus in the second  
41 wave, the country's labs could not give results within the same time frame of 12-24 hours. Labs  
42 across different cities of India such as Delhi, Mumbai, Noida, Lucknow, and Kolkata were  
43 taking an average of 3-5 days to give test results (Acharjee, May 10, 2021). Similar situations  
44 were also observed in the US. Many people needing testing had to wait for more than a week  
45 to receive the diagnosis and its report. In some cases, testing was too late. In Denver, the state  
46 testing lab, including other labs, ran out of testing kits, and a shipment was delayed (Doyle,  
47 2020). Many countries were facing a shortage of testing kits and inadequate lab capacity during  
48 2020-21.  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
*(iv) Lack of supply of COVID-19 vaccines:* COVID-19 vaccines have brought a ray of hope to people for returning to normalcy after a long period of lockdown (Warren and Lofstedt, 2021). Many manufacturing companies are trying to develop, manufacture, and fulfill the need for COVID-19 vaccines (Kim et al., 2021). The volume required for the vaccines is very high, considering, on average, two doses for each individual. To cover vaccination for 100% of the world's population, it is approximated that 16–20 billion doses are required for the current population of approximately 7 billion (Rele, 2020). The development of vaccines requires considerable time because they must be effective and safe (Singh and Mehta, 2016).

15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
Availability of vaccines is critical to reducing the potential losses from the pandemic. Governments and academic institutions will have to plan to make the availability of vaccines for the general public (Ocampo and Yamagishi, 2020). The bottlenecks in the development and deployment of the vaccines are to be removed (Rele, 2020). Guttieres et al. (2021) and Abbasi et al. (2020) proposed a framework for COVID-19 vaccination strategies considering the allocation and distribution of the COVID-19 vaccines. The three main phases of vaccines manufacturing are development, dissemination, and distribution (Forman et al., 2021). These three phases are composed of ensuring the continued growth of vaccine candidates, authorization, production, distribution, administering, and monitoring existing vaccines.

32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
*(v) Lack of awareness and hesitancy in acceptance of the vaccines:* The success of any vaccination drive depends on its coverage and acceptance rate (Pogue et al., 2020). There might be different concerns of the people regarding the vaccines (Dror et al., 2020). For wide coverage of the population by vaccination and to avoid hesitancy towards the vaccine, it is necessary to understand peoples' views regarding the vaccine. In the first phase of the COVID-19 vaccination, the healthcare and frontline workers were hesitant to receive the vaccine due to many reasons (The Wire, January 21, 2021).

46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
Experience shows that the uptake of vaccines is more complex. Vaccine uptake and the wider acceptance of vaccines is a social endeavor that requires consideration of human factors. Sponsors need to do critical investigations on human factors related to vaccine acceptance and for public health authorities and other stakeholders to act on this research's social and behavioral findings (Schoch-Spana et al., 2020).

56  
57  
58  
59  
60  
61  
*(vi) Need for Home-based-primary care services:* Due to mass suffering from COVID-19 and insufficient facilities in hospitals, the governments started to provide home-based primary care (HBPC) services. Also, a large section of the population is either homebound or needs the

1 assistance of another person to leave their homes (Ornstein et al., 2015). In this situation, HBPC  
2 provides facilities for such patients to access the required medical care in their homes (Totten  
3 et al., 2016; Stall et al., 2014). HBPC reduces the emergency department visits, minimizes the  
4 iatrogenic COVID-19 exposure, boosts COVID-19 testing, addresses chronic medical issues,  
5 and prevents the escalation of the diseases. Since a large number of hospitals are declared as  
6 COVID hospitals (Pisano et al., 2020). The main challenges observed in HBPC are lack of  
7 familiarity of the patients with telemedicine, patient anxiety, clinician anxiety, technical  
8 difficulties in reaching the patients, and supply shortages, including masks, gowns, and  
9 disinfecting materials (Ritchie, 2021).  
10

11  
12  
13  
14  
15  
16  
17 **(vii) Lack of application of advanced technologies:** Some advanced technologies are available  
18 that can be used to mitigate the risk related to the COVID-19. Abd-alrazaq et al. (2020)  
19 suggested the use of blockchain technology to fight against the COVID-19. According to them,  
20 no comprehensive reviews were conducted to uncover the blockchain solutions to improve the  
21 public health efforts against COVID-19. The most prominent use of blockchain technology is  
22 contact tracing (a process wherein individuals who have been in close contact with those who  
23 have tested positive for COVID-19 are identified) (Xu et al. 2020; Choudhury et al., 2021),  
24 immunity passports (an individual is a disease risk-free because he has already been infected  
25 with COVID-19 or was given a COVID-19 vaccine) (Eisenstadt et al., 2020), telemedical  
26 laboratory services (Celesti et al., 2020), social distancing (Garg et al., 2020), securely sharing  
27 patients' data (Khatoon, 2020), monitoring isolated people (Zheng et al., 2020), tracking and  
28 monitoring the COVID-19 status through a trusted source (Marbough et al., 2020) and, tracking  
29 and controlling the delivery of a COVID-19 vaccine (Ramirez and Beltrán, 2020).  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40

41 According to Kumar et al. (2020a), Industry 4.0 and the Internet of Things (IoT) (Narwane et  
42 al., 2020) offer excellent support for communication in the value chain. It can stop wrong  
43 interpretations of information shared among different agencies. The application of IoT can be  
44 used for the better care of the patient during the COVID-19 pandemic. Real-time monitoring  
45 of the patients suffering from another disease during the COVID-19 period (when most of the  
46 hospitals were declared as COVID hospitals) can be possible with the use of IoT. Smart medical  
47 devices can be accessed through a smartphone to transfer the required health data to the  
48 physician quickly. These devices can also collect oxygen levels, blood pressure, weight, sugar  
49 level, etc. (Javaid and Khan, 2021). Tareq et al. (2021) suggested that additive manufacturing  
50 technology can be used to rapidly produce medical equipment such as ventilators,  
51 nasopharyngeal swabs and PPE, face masks, and face shields on time with customization.  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
**(viii) Lack of supply of medical oxygen:** The availability of the medical oxygen required for sick patients is not always straightforward. The patients with moderate-severe COVID-19 may require supplemental oxygen using face masks with oxygen flow up to around 5–6 L O<sub>2</sub>/minute. Flow rates can be adjusted by monitoring the oxygen level using pulse oximetry. The level of oxygen (SpO<sub>2</sub>) must be above 88% in COVID-19. If the patient shows a desaturation level less than 88% for prolonged periods, oxygen supply to the patient can be enhanced by using a non-rebreathing mask. This can provide a fraction of inspired oxygen (FiO<sub>2</sub>) of 0.6–0.8 and needs an oxygen flow from the oxygen cylinder or piped oxygen of minimal 10–15 L/minute (Dondorp et al., 2020).

17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
There are many ways to supply oxygen to patients. The main source of the oxygen supply is oxygen manufacturing plants, transported to the hospitals in the liquid form. It is vaporized and piped to the patient who needs it. Some hospitals also use the oxygen concentrator, but it is limited to supply the oxygen to only moderate patients (The Wire, April 24, 2021). The wire (May 7, 2021) reported the details of 178 deaths due to the shortage of supply in hospitals in India. Many hospitals in India were facing an acute shortage of oxygen during the second wave in May 2021. India's daily oxygen production capacity is 7,127 metric tonnes, consumption is only 3,842 metric tonnes as per the data released by the Indian government at the beginning of April 2021, but suddenly oxygen demand increased in different states, and many hospitals faced problems due to short supply of oxygen (Bhuyan, 2021).

37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
**(ix) Medical waste disposal crisis:** During Covid-19, wide distribution of infectious materials in the form of used facemasks, gloves, and protective equipment, including food and plastic wastes, was found. Sources of these wastes are hospitals, health care centers, and quarantined households. The waste treatment plants were disrupted and forced for emergency treatment and disposals. In Wuhan city, medical waste radically increased from 40 tons/day to about 240 tons/day, exceeding the medical waste treatment capacity of 49 tons/day (Hantoko et al., 2021). It is suggested to collect the medical waste separately. However, the separate medical waste collection and treatment is challenging and needs strong coordination between health authorities and waste service management.

54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65  
In many developing countries, solid wastes, including medical wastes, are discharged in open dumping or in unsanitary landfills where waste scavengers collect recyclable materials without using protective tools (Nzediegwu and Chang, 2020). Also, livestock such as cows, goats, and dogs use the poorly managed landfills as their “food source”, which may lead to the spread of

1 diseases, including COVID-19. The COVID-19 related medical wastes must be packaged with  
2 double-layer medical waste bags and labeled as “COVID-19 infection” (Peng et al., 2020). The  
3 disinfectants should decontaminate the surface of bags before putting them into a medical  
4 container (Wang et al., 2020). The generated waste from the infected homes should also be  
5 double-layer packed and sealed before storing them in collection bins.  
6  
7

8  
9  
10 **(x) Issues related to reliability of RT-PCR test:** RT-PCR (real-time polymerase chain reaction)  
11 is used to test the infection of the COVID-19 virus. Although only 45-60% sensitivity of the  
12 test is reported (Dong et al., 2021) under the RT-PCR test, the examination of nasal and  
13 oropharyngeal swabs, nasopharyngeal washing, or aspirate is primarily recommended as a  
14 diagnosis of COVID-19 (Esbin et al., 2020). In the five different studies covering 957 suspected  
15 or confirmed patients of COVID-19, the false-negative rate ranged from 2% to 29 % (Arevalo-  
16 Rodriguez et al., 2020). False-negative results of true infected cases are considered disease-  
17 free and lead to transmitting the disease unintentionally. Unfortunately, another single  
18 molecular test also cannot guarantee the infection-free status for a suspected case. The false-  
19 negative rate of the RT-PCR test can also occur sometimes due to reasons such as viral load  
20 (Thompson and Lei, 2020), denaturation or degradation of RNA due to improper manipulation  
21 or storage (Karthik et al., 2020), replication of viral loads for a specific period, variation in  
22 viral load in different specimens of the same patient (Mallett et al., 2020).  
23  
24

25  
26  
27  
28  
29  
30  
31  
32  
33  
34 **(xi) Requirement of budgeting and rebudgeting by the Government:** The processes of  
35 budgeting and reporting are to be reconsidered to tackle the challenges of COVID-19.  
36 Governments are required to put a strong effort into the preventive and supporting roles of  
37 budgeting to lessen the public organizations’ exposure to shocks and for supporting resilience.  
38 COVID-19 has a significant impact on the budgeting process. The immediate effect has been  
39 in the form of rebudgeting (an act to amend the budget during the financial year) (Anessi-  
40 Pessina et al., 2012). In the next few years, rebudgeting is likely to be continued to face the  
41 uncertainty produced by the pandemic. The changing variants of the coronavirus pose a strong  
42 challenge to the budgeting processes. The budgeting and rebudgeting processes must be  
43 flexible and strategic to tackle the challenges of COVID-19 (Anessi-Pessina et al., 2020).  
44  
45  
46  
47  
48  
49  
50  
51  
52

53 **(xii) Collaborative approach for managing inventory and demand forecasting:** COVID-19  
54 Pandemic leads to the creation of unanticipated demand shocks, stockouts, and disruption of  
55 healthcare supply chains due to the severe impact on availability, access, and affordability of  
56 medical items (Friday et al. 2021). Most of the research articles on managing medical stocks  
57  
58  
59  
60  
61  
62  
63  
64  
65

1 focus on traditional methods such as minimizing the cost and maximizing profit. It leads to  
2 stochastic and periodic reviews, vendor-managed inventory, and the use of radio-frequency  
3 identification (Jabbarzadeh et al., 2019). However, in the context of pandemics, governments,  
4 relief organizations, and individuals deal with clogged inventory processes. Access to the  
5 optimal medical stocks during a pandemic supersedes costs and profits. The risks related to  
6 stockouts can be avoided if the medicine management follows a collaborative process planning  
7 among the key stakeholders for inventory management (Nematollahi et al., 2018).  
8  
9

10  
11  
12  
13 In both humanitarian and healthcare supply chains, demand to forecast and planning face  
14 problems due to lack of data availability, limited quality control, time-wastage, and error-prone  
15 supply chains (van der Laan et al., 2016). The overestimation of medical stocks is preferred in  
16 humanitarian supply chains, which contradicts the purpose of commercial supply chains to  
17 reduce the inventory and improve customer satisfaction. The adverse effect of the overstocking  
18 of medical items in the healthcare supply chain deteriorates due to the lack of collaborative  
19 planning, forecasting, and replenishment (CPFR) practices (Panahifar et al., 2015). Rustam et  
20 al. (2020) advocate the applications of machine learning models in the forecasting of upcoming  
21 COVID-19 affected patients. They have used four standard forecasting models: linear  
22 regression, least absolute shrinkage, selection operator, support vector machine, and  
23 exponential smoothing to forecast the threatening factors of COVID-19. The threatening  
24 factors were newly confirmed cases, the number of deaths, and the number of recoveries.  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35

36 **(xiii) Poverty and Food insecurity:** A large section of the world population is maintaining  
37 some forms of social distancing to contain the health crisis. As a result, millions of businesses  
38 closed their activities. A large number of workers became unemployed. The government of  
39 developed countries like the USA and the UK has promised to compensate for the income  
40 losses of businesses and workers and to contain an inevitable economic crisis. But the relief  
41 responses of low- and middle-income countries are limited (Laborde et al., 2020).  
42  
43  
44  
45  
46

47  
48 The lack of food security and increasing poverty is a major issue for underdeveloped and  
49 developing countries (Kumar and Singh, 2021a). Low-income countries are facing challenges  
50 related to ensuring the availability of nutritious and safe food to poor people (Pingali et al.,  
51 2017). The availability of food grains is crucial because a large section of the population cannot  
52 get the food (Clapp 2017). The central and state governments share the responsibility to provide  
53 food grains to the targeted population (Reardon et al. 2019).  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65

(xiv) **Lack of skilled manpower:** Increasing community transmission of COVID-19 infections, inadequate testing capacity, and overwhelming health resources lead to the shortages of the skilled health workforce. To fulfill the requirement of a skilled health workforce, it is necessary to bring community health workers (CHW) on board (Ajisegiri et al., 2020). Engagement of the CHW should be done at the earlier stage to hamper outbreak response and primary health services. The shortages of skilled workforce are also observed in other sectors due to social distancing, lockdown, and government instruction to use only one-third of the workers at a time. Kumar and Singh (2021a) have highlighted the issue of shortage and migration of the skilled workforce in agri-food supply chains due to the outbreak of COVID-19.

All the challenges as discussed above in context to humanitarian supply chains because of the pandemic are summarized in Table 3.

**Table 3: Challenges in Humanitarian supply chain during COVID-19**

| Challenges  | References  | Description   |
|---|---|---|
| Lack of planning and preparedness                             | Villa et al. (2020), Lancet (2020).   | This is concerned with the failure of the policy to contain the spread of COVID-19 and poor preparedness to face the challenges of the pandemic outbreak.   |
| Extended shortages  | HHS (2020), CBS News (2020a, b).  | This is related to the shortages of medical and other relief items such as N95 masks, PPE kits, medicine, ventilators, oxygen cylinders, etc.   |
| Inadequate lab capacity                                       | Acharjee (May 10, 2021), Doyle (2020).  | It means the available capacity of the lab for COVID-19 testing is not sufficient, and it delays the report of the testing.   |
| Lack of supply of COVID-19 vaccines                           | Rele (2020), Singh and Mehta (2016), Ocampo and Yamagishi (2020), Abbasi et al. (2020), Alam et al. (2021). | Due to the lack of supply of COVID-19 vaccines, the distribution is managed in different phases. In the first phase, the vaccines are provided to health workers and people above 60 years. The second phase is considered for people of more than 45 years, and the third phase is for people of more than 18 years. |
| Lack of awareness and hesitancy in acceptance of the vaccines | Pogue et al. (2020), Dror et al. (2020), Schoch-Spana et al. (2020).  | Lack of awareness and hesitancy in acceptance of the vaccines defeat the purpose of vaccination. It is necessary to address the concerns of the population and bridge the communication gaps.   |

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65

Need of Home-based-primary care services (HBPC)

Ornstein et al. (2015),  
Totten et al. (2016),  
Stall et al. (2014),  
Pisano et al. (2020).

Due to shortages of beds, hospitals and healthcare facilities are provided to only critical patients. The moderate patients are suggested to home quarantine and get the services of HBPC.

Lack of application of advanced technologies

Abd-alrazaq et al. (2020),  
Kumar et al. (2020a),  
Narwane et al. (2020),  
Tareq et al. (2021),  
Javaid and Khan (2021).

It is concerned with the application of Blockchain technology, IoT, Big data analytics, Cloud of Things, Additive manufacturing in data monitoring, telemedicine, home care of patients, and rapid production of medical equipment.

Lack of supply of medical oxygen

Dondorp et al. (2020),  
The Wire (April 24, 2021)

The lack of supply of oxygen cylinders was observed in the second phase of COVID-19 in India. Due to uneven distribution and an increase in a sudden demand for oxygen cylinders, many hospitals run out of oxygen, resulting in the death of many patients in different hospitals.

Medical waste disposal crisis

Hantoko et al. (2021),  
Nzediegwu and Chang (2020), Wang et al. (2020).

COVID-19 medical wastes are highly infectious, and separate treatment of the medical waste and other waste became challenging for developing and low-income countries.

Issues related to reliability of RT-PCR test

Esbin et al. (2020),  
Dong et al. (2021),  
Arevalo-Rodriguez et al. (2020), Thompson and Lei (2020)

The sensitivity of the RT-PCR test is limited to only 45-60%, and the false-negative rate ranged from 2% to 29%. Thus, it also threatens to spread the virus through the infected people as they declared false negatives.

Requirement of budgeting and rebudgeting by the government

Anessi-Pessina et al. (2012), Anessi-Pessina et al. (2020).

Rebudgeting is an act to amend the budget during the financial year to meet the immediate impact of COVID-19. Due to uncertainty in the spread of the pandemic, special budgeting and rebudgeting are required to meet the challenges.

A collaborative approach to maintaining optimal inventory and demand forecasting for humanitarian logistics

Friday et al. (2021),  
Jabbarzadeh et al. (2019), van der Laan et al. (2016), Panahifar et al. (2015), Rustam et al. (2020).

It is concerned with the collaborative decision-making related to inventory management of the medical items and forecasting the pandemics' spread.

|                             |   |   |
|-----------------------------|---|---|
| Poverty and Food insecurity | Laborde et al. (2020), Kumar and Singh (2021a), Pingali et al. (2017), Clapp (2017), Reardon et al. (2019), Kumar et al. (2020b). | The poverty level has increased due to the disruption of all the business and production activities. Unemployment has also increased, which leads to food security problems among poor people.  |
| Lack of skilled manpower    | Ajisehiri et al. (2020), Kumar and Singh (2021a).   | Due to the sudden outbreak and rapid spread of the coronavirus, the demand for skilled manpower is increased. On the other hand, due to social distancing, lockdown, and migration of workers, lack of availability of workers has been observed. |

### 3.2.2 Learnings from COVID-19

The severe impact of disasters across the world has attracted the attention of governments, policymakers, non-governmental organizations, and scholars (Dubey et al., 2019a). The pandemic COVID-19 has not only affected the business of several organizations, but it also affected the social and personal life of the people globally across all countries. Many organizations stopped their operations due to a shortage of resources required. Recently, many research articles covering COVID-19 have discussed chaotic situations and their impact on the lives of people. After analyzing challenges, we are discussing some of the learnings for managing HSC in the future.

**Preparedness:** The preparedness of any system gives the ability to face any kind of disruptions like the COVID-19 outbreak. Preparedness is equally important for the humanitarian supply chains and commercial supply chains. This pandemic has taught many lessons to the management of the organizations and supply chains. It is observed that how the preparedness of a supply chain is crucial for a health care industry. Supply chains are to be efficiently managed considering risk and disruption at both supply chain and organizational levels (Whitten et al., 2012). The COVID-19 pandemic has already exposed the vulnerabilities of key industry players, especially those who have a high dependence on international trades in fulfilling their requirements.

Jahre (2017) worked on finding the strategies to improve logistics preparedness in humanitarian supply chains. He observed that better preparedness improves response even if there is a trade-off between cost efficiency and flexibility. Logistics preparedness is mainly

1 concerned with network design and warehouse location for prepositioning of goods (Kunz and  
2 Reiner, 2012). Prepositioning can be viewed as only one among many strategies for the  
3 strategic stock of medical items, especially in the case of pandemic and disaster management.  
4 Tomasini and Wassenhove (2009) differentiated the characteristics of the humanitarian supply  
5 chain and commercial supply chain. They used the case study methodology to observe the role  
6 of preparedness, response, and collaboration for the private and humanitarian sectors to work  
7 together towards social improvements. They implemented these three agendas (preparedness,  
8 response, and collaboration) to collaborate with humanitarian organizations and private  
9 businesses to develop the case studies. Kovacs and Sigala (2021) discussed the learnings from  
10 HSCs that mitigate the risks and overcome supply chain disruptions. These lessons relate to  
11 preparedness and mobilization, including standardization, innovation, and collaboration.  
12 Logistics preparedness is equally important in commercial as well as humanitarian supply  
13 chains for mobilization of the various resources required.  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23

24 For a pandemic situation, preparedness must lead to the activities to ensure rapid detection of  
25 cases and comprehensive response. The preparedness includes the response plans, training of  
26 response teams, prepositioning of relief items including medical equipment and medicines, and  
27 preparing treatment centers. These activities may be decentralized rapidly to be ahead of the  
28 spread of the disease (Mobula et al. 2020).  
29  
30  
31  
32  
33

34 ***Prepositioning of relief items:*** In the initial phase of COVID-19, many countries faced a  
35 shortage of medical items such as facemasks, PPE kits, ventilators, oxygen cylinders, etc. The  
36 humanitarian organizations have been using prepositioning the relief items as a crucial strategy  
37 to prepare for disasters including pandemics. Humanitarian organizations carry the  
38 prepositioning inventory of the items either alone or jointly (Toyasaki et al., 2017).  
39 Prepositioning of relief items is an effective method for disaster preparedness (Bai et al., 2018).  
40 Pre-disaster planning and prepositioning the relief items are important in quickly sending the  
41 relief items in the disaster zone (Thomas and Kopczak, 2005). Prepositioning of relief items is  
42 considered a key component of humanitarian logistics (Opit and Nakade, 2015). It is observed  
43 that humanitarian organizations should attempt to hire a strategic warehouse for prepositioning  
44 of relief items (Torabi et al., 2018; Sharifi-Sedeh et al., 2020). Recently, many countries have  
45 started to pre-position ventilators, PPE, therapeutics, and laboratory equipment for the  
46 pandemic response of COVID-19. COVID-19 is not completely eradicated till date i.e. October  
47 2021. The second phase of COVID-19 has already been observed in some countries, and the  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65

third wave is expected as predicted by experts. In this situation, forecasting the relief/medical items based on the first and second wave of COVID-19 has become very important.

**Joint procurement:** It is a long history to use joint procurement in the humanitarian supply chain (Herlin & Pazirandeh, 2015). In the COVID-19 response, many organizations are using joint procurement. For example, the International Federation of Red Cross and Red Crescent Societies (IFRC) coordinates the procurement activities in the Red Cross Movement. Similarly, the COVAX coordinates the procurement of COVID-19 vaccines and other necessary items for their administration. Joint purchasing of items leads to low purchase prices, improved product quality, and long-term relationship with suppliers that reduces the risk of supply shortage (Schulz and Blecken, 2010). Joint purchasing between multiple humanitarian organizations is an effective way to manage the purchase of complex products and services.

**Multiple sourcing:** Before the COVID-19 Pandemic, it has been a general trend to use lean manufacturing and to reduce the number of suppliers and contract manufacturers (Cozzolino et al., 2012). However, it does not work when the logistics systems are completely disrupted (Yang et al., 2019). During the first wave of COVID-19, the entire supply chain was disrupted, and most of the humanitarian organizations, hospitals, government agencies, and private organizations were observing the lack of supply of relief items. Now, organizations are not relying on single suppliers rather planning to take multiple sourcing (Haque & Islam, 2018; Kovacs and Sigala, 2021).

**Needs assessment:** There are some general characteristics of the humanitarian supply chains such as operations in a chaotic environment, unpredictability, uncertainty, rapid changes and deployment in demand, ad hoc project supply chains, etc. (Sigala et al., 2020). Need assessment is very important for planning the actions to be taken to fulfill the needs of the beneficiaries. It is the needs of the beneficiaries in terms of the relief items and locations considering the vulnerabilities and capacities of the beneficiaries (Blecken, 2010; Kovacs and Sigala, 2021).

**Collaboration among partners:** Collaboration among private and government agencies has been very important during the first wave of COVID-19. Many manufacturing organizations changed their production plans during COVID-19. In some cases, the production changeover was government initiated to produce respiratory ventilators. For example, Mahindra and Mahindra have indigenously developed a prototype of a bag valve mask, which is commonly known as an Ambu bag within the cost of Rs. 7,500 (Mint, March 27, 2020). Maruti Suzuki

1 India Ltd signed a Memorandum of Understanding (MoU) with the AgVa on March 30 and  
2 has produced 1,250 ventilators to date (Mint, April 24, 2020).  
3

4 Reliance Industry Ltd has set up India's first dedicated coronavirus hospital for 1,000 beds (The Hindu,  
5 March 23, 2020). Similarly, during the second wave of COVID-19 in 2021, many private and public  
6 sector companies started to supply oxygen cylinders to different hospitals in India. Many other  
7 companies observed new business opportunities related to the production of hand sanitizers  
8 and personal protective equipment. Collaboration between different sectors and partnerships  
9 between public and private sectors have become more important for supply chain resilience in  
10 disaster-affected areas (Tomasini & Van Wassenhove, 2009; Van Wassenhove, 2006).  
11  
12

13 **Coordination:** A proper coordination among the actors of humanitarian logistics plays an  
14 important role in the relief operations. Sabri et al. (2019) treated it as a fundamental challenge  
15 in a sustainable humanitarian supply chain. It may result in a lack of communication, lack of  
16 clear policies, ineffective distribution of relief items, and stagnation of relief activities (Vega,  
17 2018). Coordination, as a key challenge in humanitarian activities, is a systematic set of  
18 involvements that should safeguard and protect vulnerable groups (Begum and Momen, 2019).  
19 The coordination in the value chain has numerous complications. Saleh and Karia (2020)  
20 interviewed many leaders and highlighted some important directions of the coordination, such  
21 as coordination among the international NGOs, coordination between the existed interagency  
22 platforms, coordination with the wider international NGOs internal structures, and coordination  
23 with the government.  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37

38 Coordination between the actors engaged in relief operations leads to improvement in the  
39 resilience and efficiency of humanitarian supply chains (Singh et al. 2018). It also leads to  
40 effective and efficient utilization of the resources and minimizes the cost of the other items to  
41 be procured. It also reduces the operational costs and the response time for providing better  
42 services (Akhtar et al. 2012). Balcik et al. (2010) proposed some important factors affecting  
43 coordination. These are "diversity, donors' expectations, funding structures, competition for  
44 funding, uncertainty, resource scarcity, and oversupply". Lack of coordination among actors  
45 may result in the prolongation of the suffering of the people (Jin et al. 2015). Dubey et al.  
46 (2018) studied big data and predictive analytics for improving visibility and coordination in  
47 humanitarian supply chains. They found that swift trust is not the condition for improving  
48 coordination among the actors in humanitarian supply chains.  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65

1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
**Swift trust and commitment:** Trust is an essential component of both organizational and team phenomena. Trust affects performance in terms of enhancing intra- and inter-organizational cooperation, coordination, and control. Swift trust is a presumptive form of trust, and it was introduced to explain the paradoxical trusting behavior shown by members of new temporary formed teams (Meyerson et al., 1996; Xu et al., 2007). In these temporary teams, an individual who had no past working relationships with other members immediately forms trust and engages himself in trusting behaviors. Swift trust may be defined as the willingness to rely upon team members to perform their roles in a hastily formed temporary team (Zolin, 2002). Dubey et al. (2019b) studied the application of big data analytics in enhancing the swift trust and collaborative performance between civil and military organizations engaged in disaster relief operations.

21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
Hocutt (1998) defined the term commitment as “the intention to continue a course of action or activity”. Trust and commitment have been treated as the two most important factors to make stronger coordination among actors (Conway and Swift, 2000). Wilson (1995) also identified trust as an important factor for improving a relationship. Miettala and Moller (1990) stated that trust is the prerequisite for enhancing commitment. Commitment has been observed as a key driver of coordination (Kabra and Ramesh, 2015).

32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
**Risk management:** Humanitarian supply chains play an important role in effective and efficient disaster relief operations. Several risks have been observed in Humanitarian supply chains. However, there is no common approach, and its applicability has been studied to deal with these risks through recent cases (Baharmand et al., 2017). Kumar and Singh (2021a) studied the impact of COVID-19 on agri-food supply chains and observed that import disruptions, transport restrictions, supply and distribution uncertainties, price volatility, capital shortage, lack of food securities, etc. are some major issues to manage. Procurement risk is also highlighted by some of the authors. Iakovou et al. (2014) advised dual sourcing as a proactive risk mitigation sourcing strategy.

49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
**Information sharing:** Right information at the right time plays a key role in relief operations. Many sources started to work to spread the information during the disaster and led to a chaotic situation (Kumar and Singh, 2021b). Information sharing is consistently underestimated in the HSC (Ergun et al., 2014). Information sharing is an urgent need of humanitarian supply chains. The real-time data collection and its processing must be reliable and consistent. The information-sharing develops trust among the humanitarian organizations and actors.

1 Information sharing is treated as an important driver of success during a crisis (Gunasekaran  
2 and Ngai, 2003).

3  
4 **Response time:** On-time delivery of relief items to the affected people is essential for an  
5 efficient and effective humanitarian supply chain (Abidi et al. 2013). Dubey et al. (2020)  
6 studied the impact of antecedents such as information sharing, supply chain visibility, swift  
7 trust, commitment, and collaboration on the agility of humanitarian supply chains. Dubey and  
8 Gunasekaran (2016) used interpretive structural modeling to link the characteristics of  
9 sustainable humanitarian supply chains in terms of agility, adaptability, and alignment.  
10 Disasters may be divided into two classes: Slow onset disasters and sudden-onset disasters  
11 (Jabbour et al. 2019). In slow-onset disasters, a small duration of time interval is available to  
12 organize the relief operations. But, when sudden-onset disasters occur, a quick response is  
13 required, and no time is available for proper planning and activities. The main requirement  
14 during the crisis is to supply the relief items at the right time in the right location to minimize  
15 the impact of the disasters. The initial few days just after a disaster are crucial to meet the  
16 challenge of providing emergency relief (Tatham and Kovacs 2007). During COVID-19,  
17 response time for the patient needed ventilator support, and oxygen supply were crucial. Thus,  
18 response time is influential in pandemic outbreaks.  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31

32 **Supply chain visibility:** Visibility is one of the critical factors for high performance in  
33 commercial as well as humanitarian supply chains (Choi and Sethi, 2010). Visibility is vital  
34 when the actor needs access to information regarding materials/relief items across the supply  
35 chain (Klueber and O'Keefe, 2013). Lack of visibility can result in overstocking of unwanted  
36 items and understocking of urgently needed supplies. Supply chain visibility recently gained  
37 the specific attention of researchers and practitioners. Dubey et al. (2020) found the relationship  
38 between information sharing, supply chain visibility, and swift trust for managing HSC.  
39 Information sharing influences supply chain visibility and develops swift trust among the  
40 humanitarian organizations and actors in disaster relief operations. During the second wave of  
41 COVID-19 in India, lack of visibility and information sharing among stakeholders created  
42 many problems for human beings. All the above learnings identified after the outbreak of  
43 COVID-19 are summarised in Table 4.  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65

**Table 4: Learnings from COVID-19 for managing Humanitarian supply chains**

| <b>Factors</b>                 | <b>References</b>  | <b>Remarks</b>  |
|--------------------------------|--|---|
| Preparedness                   | Whitten et al. (2012), Jahre (2017), Tomasini and Wassenhove (2009), Kovacs and Sigala (2021), Mobula et al. (2020). | It leads to the ability to face any emergent situation. It is concerned with all the logistics and humanitarian preparation for the probable disasters.   |
| Prepositioning of relief items | Toyasaki et al. (2017), Bai et al. (2018), Torabi et al. (2018), Sharifi-Sedeh et al. (2020).                        | Prepositioning is a strategy to maintain the inventory of the relief items at different locations, either alone or jointly, to prepare for disasters, including pandemics.  |
| Joint procurement              | Herlin & Pazirandeh (2015), Schulz and Blecken (2010).   | Joint purchasing of items leads to low purchase prices, improved product quality, and long-term relationship with suppliers that reduces the risk of supply shortage.   |
| Multiple sourcing              | Cozzolino et al. (2012), Yang et al. (2019), Haque & Islam (2018), Kovacs and Sigala (2021).                         | Multiple sourcing is concerned with the procurement of more than one source to ensure the on-time supply of the relief items.   |
| Needs assessment               | Blecken (2010), Kovacs and Sigala (2021)   | Need assessment is very important for planning the actions to be taken to fulfill the needs of the beneficiaries.   |
| Collaboration                  | Balcik et al. (2010), Tomasini & Van Wassenhove (2009), Van Wassenhove (2006).                                       | Cross-sector collaboration and public-private sector partnerships become very important for supply chain resilience in disaster-affected areas. Many companies observed new business opportunities related to the production of medical items during the pandemics. |
| Coordination                   | Vega (2018), Begum and Momen (2019), Saleh and Karia (2020), Balcik et al. (2010).                                   | Proper coordination among the actors of humanitarian logistics plays a vital role in relief operations. It leads to effective utilization of the resources and minimizes the cost of the other items to be procured.  |
| Swift trust and commitment     | Meyerson et al. (1996), Xu et al. (2007), Hocutt (1998), Miettala and Moller (1990).                                 | Swift trust is a presumptive form of trust, and it was introduced to explain the paradoxical trusting behavior shown by members of new temporary formed teams. Commitment is intended to continue a course of action or activity.                                   |

|    |               |   |
|----|---------------|---|
|    |               | Trust is the precondition for enhancing commitment. |
| 1  |               |   |
| 2  |               |   |
| 3  | Risk          | Baharmand et al. (2017),                            |
| 4  | management    | Kumar and Singh (2021a),                            |
| 5  |               | Iakovou et al. (2014).                              |
| 6  |               |   |
| 7  |               |   |
| 8  |               |   |
| 9  |               |   |
| 10 | Information   | Kumar and Singh (2021b),                            |
| 11 | sharing       | Ergun et al. (2014),                                |
| 12 |               | Gunasekaran and                                     |
| 13 |               | Ngai (2003).  |
| 14 |               |   |
| 15 |               |   |
| 16 |               |   |
| 17 | Response time | Abidi et al. (2013), Jabbour                        |
| 18 |               | et al. (2019), Tatham and                           |
| 19 |               | Kovacs (2007).                                      |
| 20 |               |   |
| 21 |               |   |
| 22 |               |   |
| 23 |               |   |
| 24 |               |   |
| 25 | Supply chain  | Choi and Sethi (2010),                              |
| 26 | visibility    | Klueber and O'Keefe                                 |
| 27 |               | (2013), Dubey et al. (2020).                        |
| 28 |               |   |
| 29 |               |   |
| 30 |               |   |
| 31 |               |   |
| 32 |               |   |
| 33 |               |   |
| 34 |               |   |
| 35 |               |   |
| 36 |               |   |
| 37 |               |   |
| 38 |               |   |
| 39 |               |   |
| 40 |               |   |
| 41 |               |   |
| 42 |               |   |
| 43 |               |   |
| 44 |               |   |
| 45 |               |   |
| 46 |               |   |
| 47 |               |   |
| 48 |               |   |
| 49 |               |   |
| 50 |               |   |
| 51 |               |   |
| 52 |               |   |
| 53 |               |   |
| 54 |               |   |
| 55 |               |   |
| 56 |               |   |
| 57 |               |   |
| 58 |               |   |
| 59 |               |   |
| 60 |               |   |
| 61 |               |   |
| 62 |               |   |
| 63 |               |   |
| 64 |               |   |
| 65 |               |   |

#### 4. Research gaps and directions for future research

Due to lack of decision-making and medical protocol, the pandemic outbreaks lead to the worst situation and cause lives of the people in mass. It has been a big question that how to manage the relief operations so that substantial disruption of humanitarian supply chains can be avoided without compromising the essential services, including access to health. The availability of the relief items, including the medical items, is to be insured by the proper inventory management. During the pandemic, all the different actors try to maintain a high inventory level without considering the exact demand. This is the second important question, which is concerned with the strategy to be explored to make an effective inventory planning and demand forecasting.

The pandemic outbreaks cause infectious disease due to which people maintain social distancing, home quarantine, and other precautions. In this situation, the coordination of the relief activities among the actors becomes very difficult. This leads to finding a way to improve the coordination among the aid actors. The application of advanced technology may support relief operations. These technologies and the mechanism of their implementation are to be

1 explored. For example, blockchain technology, IoT, Cloud computing, robotic application in  
2 medical waste handling, additive manufacturing in the rapid production of medical items may  
3 be supportive. After analyzing the challenges in Humanitarian supply chains, we have explored  
4 different learnings from the COVID-19 pandemic. Based on the literature, some of the research  
5 gaps, research questions, and future research directions are summarised in Table 5.  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65

**Table 5: Summary of the research gaps, research questions, and future research directions.**

| <b>Research Gaps/emerging issues</b>   | <b>Open research questions (ORQ) and opportunities</b>   | <b>Future Research Directions</b>  |
|--|--|--|
| <p>1. Strategy to reduce mortality, and ensure that vulnerable people, refugees, and displaced populations have access to testing, referral, and definitive treatment alongside all populations.</p> | <p>ORQ1: How to avoid the substantial disruptions to humanitarian operations without compromising access to health and other essential services, and the ability to respond to urgent community needs?</p> | <ul style="list-style-type: none"> <li>• COVID-19 has failed the existing approach of lean operations, single sourcing, and inventory minimization. Therefore, there is a need for new business models in the prevailing post COVID scenario.</li> <li>• During COVID-19, lack of strategy and unpreparedness of different agencies were observed. Government and healthcare organizations will have to find the solution that if a similar type of pandemics repeats how quickly HSC can be geared up.</li> <li>• Some essential items are to be prepositioned in HSC. Future research should suggest optimization models to find the optimum volume of the items and the suitable locations for prepositions.</li> </ul> |
| <p>2. Before the COVID-19 pandemic, companies focused on contract manufacturing, lean</p>  | <p>ORQ2: What should be the strategy for resource sharing</p>  | <ul style="list-style-type: none"> <li>• Joint procurement of essential items from different sources and their feasibility during the time of disaster should be explored as a part of future studies.</li> </ul>  |

16  
17  
18  
19  
20  
21 manufacturing, offshoring, and  
22 outsourcing. These strategies  
23 did not work at the time of  
24  
25 disruptions.  
26  
27

28  
29 3. Past epidemic scenarios show  
30 that aid coordination systems  
31 need to improve across agencies  
32 and the UN clusters as a whole.  
33  
34  
35

36  
37  
38  
39  
40  
41  
42  
43  
44  
45 4. The availability of time to  
46 respond in sudden-onset  
47 disaster/ new pandemic is very  
48 less which results in a big loss in  
49 the form of lives of the  
50 population.  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65

and avoiding single-sourcing  
during the pandemic situation?

ORQ3: How to improve the  
coordination among the  
different aid agencies during  
the pandemic?

ORQ4: How to reduce the  
response time to provide relief  
in the case of pandemic  
outbreaks where no medical  
protocol is available?

- The possibilities of multiple sourcing and local sourcing are to be explored during the pandemics.
- During and post-disaster, swift trust among the different actors of the humanitarian supply chain and proper coordination are required. Researchers should explore strategies to establish the swift-trust and proper coordination without loss of time.
- The researchers should propose a coordination mechanism between the governments and citizens for a proper flow of the right information from top to bottom to avoid any chaotic situation.
- The researchers should suggest a mechanism of collaboration among different government and private partners and international and national NGOs so that decisions could be taken on time.
- Distribution and supply of essential items such as oxygen and some medicines were observed as a major challenge during the COVID-19 outbreak. Therefore,

16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65

5. To establish a proper communication channel between the health care service providers and patient, use of telemedicine, maintaining and monitoring of data related to the pandemic.

ORQ5: How to implement the emerging technologies in the humanitarian supply chain to address the various challenges during pandemics?

optimization of the distribution network of such critical items can be further studied as a future scope.

- Lack of use of technology in the health sector and humanitarian operations has also created many challenges, so future studies should be done on the application of emerging technologies in managing HSCs during pandemics.
- Effective tracking of lifesaving items such as oxygen, medicines, and ventilators had been a major challenge. Future research should explore applying technologies such as Blockchain, RFID, and IOT for this purpose.

6. In the case of a pandemic outbreak, the quick management of medical resources and effective planning and preparedness has not been observed in most of the regions of the world

ORQ6: How can medical items be categorized according to their use and availability, and do effective planning for the unexpected future?

- The methods for classification of the medical items based on availability, utility, and self-life, annual values need to be explored to avoid the unforeseen future.

## 5. Conclusion, limitations, and implications

Managing HSC has always been a challenge for all stakeholders due to many uncertainties and the diversity of actors involved across different processes. Operations or processes of HSC are not well defined, as in the case of the commercial supply chain. Although COVID-19 has caused a lot of loss to society and business, it has given different learnings also for managing HSC, specifically during the pandemic. Therefore, in this study, we have tried to capture different learnings after reviewing different research papers published on COVID-19. Although many research articles have been published on different pandemics, very few articles have addressed the issues of the HSC. Mostly the articles published during 2020-21 on COVID-19 are considered for exploring new learnings to manage humanitarian supply chains. COVID-19's first-time outbreak happened in 2019. Before COVID-19, other pandemics had been observed, but these were limited to a specific zone or region. In this study, VOS viewer is used to demonstrate the networking amongst the authors and co-authors, and keywords. The observation through the literature review is also validated through the feedback of the respondents by interviewing them. Some regional/specific problems are incorporated in this study through interviews of the respondents, which were not addressed properly in the past literature.

Most of the old pandemic outbreaks-related articles are not addressing the issues of HSC. The first time, a global threat of COVID-19 is observed in December 2019 and continues till date. In 1918, a similar type of pandemic named Spanish flue was observed, which caused the death of millions of people. COVID-19 has caused the death of millions of people throughout the world. All the business and daily life activities, including global logistics operations, are disrupted due to this pandemic. All countries faced challenges such as shortage of relief items, medical equipment, and medicines, food items, etc. Based on the analysis, some of the major challenges observed during the pandemic are lack of planning and preparedness due to the sudden spread of a completely new type of disease and unexpected results, extended shortage due to disruption of the global supply chains and production systems, lack of supply of medical items due to increase in the demand throughout the world, unavailability of the technology to contain the spread of the disease, and poverty of the food security. Similarly, we have also learned many things from the spread of the pandemic COVID-19 such as preparedness of HSC professionals on time, strategies to preposition the essential items, coordination and collaboration among stakeholders, accurate information sharing among all stakeholders, and tracking of inventory, etc. The directions for future research have also been recommended to

1 optimize resources and distribution networks of essential items in HSCs. Researchers should  
2 also find solutions for overcoming sudden challenges due to disruptions. Prediction of the  
3 COVID-19 wave had been a major challenge, and no accurate forecasting models are available  
4 for it. Researchers should explore how data analytics can be used for predicting the next wave  
5 of COVID-19 or any other possible pandemic. The application of emerging technologies across  
6 different functions of HSC is not well explored in available studies. So future studies can be  
7 done on the application of emerging Industry 4.0 technologies for better management of HSCs  
8 at the time of pandemics. **The major contribution of this study is to highlight the challenges**  
9 **during the spread of the new type of pandemic. Major learnings from the spread of COVID-**  
10 **19 have been also researched for effective management of humanitarian supply chains.**

11  
12  
13  
14  
15  
16  
17  
18  
19 **Acknowledgement-** Authors would like to express sincere thanks to Editor and Anonymous  
20 reviewers for giving constructive inputs and suggestions on our paper.  
21  
22

## 23 **References**

24  
25 Abbasi, B., Fadaki, M., Kokshagina, O., Saeed, N., & Chhetri, P. (2020). Modeling Vaccine  
26 Allocations in the COVID-19 Pandemic: A Case Study in Australia. *Available at SSRN*  
27 *3744520*.

28  
29  
30 Abd-alrazaq, A. A., Alajlani, M., Alhuwail, D., Erbad, A., Giannicchi, A., Shah, Z., ... &  
31 Househ, M. (2020). Blockchain technologies to mitigate COVID-19 challenges: A scoping  
32 review. *Computer Methods and Programs in Biomedicine Update 1*, 100001.

33  
34  
35 Abidi, H., de Leeuw, S., & Klumpp, M. (2013). Measuring success in humanitarian supply  
36 chains. *International Journal of Business and Management Invention*, 2(8), 31–39.

37  
38  
39 Acuña-Soto, R., Stahle, D. W., Cleaveland, M. K., & Therrell, M. D. (2002). Megadrought and  
40 megadeath in 16th century Mexico. *Emerging infectious diseases*, 8(4), 360.

41  
42  
43 Ajisehiri, W., Odusanya, O., & Joshi, R. (2020). Covid-19 outbreak situation in Nigeria and  
44 the need for effective engagement of community health workers for epidemic response. *Global*  
45 *Biosecurity*, 1(4). <https://jglobalbiosecurity.com/articles/10.31646/gbio.69/>

46  
47 Akbarpour, M., Torabi, S. A., & Ghavamifar, A. (2020). Designing an integrated  
48 pharmaceutical relief chain network under demand uncertainty. *Transportation Research Part*  
49 *E: Logistics and Transportation Review*, 136, 101867.

50  
51  
52 Akhtar, P., Marr, N. E., & Garnevska, E. V. (2012). Coordination in humanitarian relief chains:  
53 chain coordinators. *Journal of Humanitarian Logistics and Supply Chain Management*. 2(1),  
54 85–103.

55  
56  
57 Akin, L., & Gözel, M. G. (2020). Understanding dynamics of pandemics. *Turkish journal of*  
58 *medical sciences*, 50(SI-1), 515-519.

1 Alam, S. T., Ahmed, S., Ali, S. M., Sarker, S., & Kabir, G. (2021). Challenges to COVID-19  
2 vaccine supply chain: Implications for sustainable development goals. *International Journal of*  
3 *Production Economics*, 239, 108193.

4 Allahi, F., Fateh, A., Revetria, R., & Cianci, R. (2021). The COVID-19 epidemic and  
5 evaluating the corresponding responses to crisis management in refugees: a system dynamic  
6 approach. *Journal of Humanitarian Logistics and Supply Chain Management*, 11(2), 347-366.  
7  
8

9 Anessi-Pessina, E., Barbera, C., Langella, C., Manes-Rossi, F., Sancino, A., Sicilia, M., &  
10 Steccolini, I. (2020). Reconsidering public budgeting after the COVID-19 outbreak: key  
11 lessons and future challenges. *Journal of Public Budgeting, Accounting & Financial*  
12 *Management*, 32(5), 957-965.  
13  
14  
15

16 Anessi- Pessina, E., Sicilia, M., & Steccolini, I. (2012). Budgeting and rebudgeting in local  
17 governments: Siamese twins?. *Public Administration Review*, 72(6), 875-884.  
18  
19

20 Anparasan, A. A., & Lejeune, M. A. (2018). Data laboratory for supply chain response models  
21 during epidemic outbreaks. *Annals of Operations Research*, 270(1), 53-64.  
22  
23

24 Anparasan, A., & Lejeune, M. (2017). Analyzing the response to epidemics: concept of  
25 evidence-based Haddon matrix. *Journal of Humanitarian Logistics and Supply Chain*  
26 *Management*, 7(3), 266-283.  
27  
28

29 Antonovics, J., Hood, M. E., & Baker, C. H. (2006). Was the 1918 flu avian in  
30 origin?. *Nature*, 440(7088), E9-E9.  
31  
32

33 Arevalo-Rodriguez, I., Buitrago-Garcia, D., Simancas-Racines, D., Zambrano-Achig, P., Del  
34 Campo, R., Ciapponi, A., ... & Zamora, J. (2020). False-negative results of initial RT-PCR  
35 assays for COVID-19: a systematic review. *PloS one*, 15(12), e0242958.  
36  
37

38 Baharmand, H., Comes, T., & Lauras, M. (2017). Managing in-country transportation risks in  
39 humanitarian supply chains by logistics service providers: Insights from the 2015 Nepal  
40 earthquake. *International Journal of Disaster Risk Reduction*, 24, 549-559.  
41  
42

43 Bai, X., Gao, J., & Liu, Y. (2018). Prepositioning emergency supplies under uncertainty: a  
44 parametric optimization method. *Engineering Optimization*, 50(7), 1114-1133.  
45

46 Balcik, B., & Beamon, B. M. (2008). Facility location in humanitarian relief. *International*  
47 *Journal of logistics*, 11(2), 101-121.  
48

49 Balcik, B., Beamon, B. M., Krejci, C. C., Muramatsu, K. M., & Ramirez, M. (2010).  
50 Coordination in humanitarian relief chains: Practices, challenges and  
51 opportunities. *International Journal of Production Economics*, 126(1), 22-34.  
52  
53

54 Baveja, A., Kapoor, A., & Melamed, B. (2020). Stopping Covid-19: A pandemic-management  
55 service value chain approach. *Annals of Operations Research*, 1. [https://doi: 10.1007/s10479-020-03635-3](https://doi.org/10.1007/s10479-020-03635-3)  
56  
57  
58

1 Begum, M. M., & Momen, M. N. (2019). Coordination does matter for disaster management  
2 in Bangladesh. In *Disaster Risk Reduction* (pp. 19-35). Palgrave Macmillan, Singapore.

3  
4 Bhuyan, A. (2021). Experts criticise India's complacency over COVID-19. *The*  
5 *Lancet*, 397(10285), 1611-1612.

6  
7  
8 Blecken, A. (2010). Supply chain process modelling for humanitarian  
9 organizations. *International Journal of Physical Distribution & Logistics Management*, 40(8-  
10 9), 675-692.

11  
12  
13 *BMJ* (2021) Covid-19: India sees record deaths as “black fungus” spreads fear.  
14 DOI: <https://doi.org/10.1136/bmj.n1238> (Published 13 May 2021)

15  
16 Burki, T. (2020). Outbreak of coronavirus disease 2019. *The Lancet Infectious Diseases*, 20(3),  
17 292-293.

18  
19  
20 Castillo, J. G. (2021). Deciding between cash-based and in-kind distributions during  
21 humanitarian emergencies. *Journal of Humanitarian Logistics and Supply Chain Management*,  
22 11(2) 272-295.

23  
24  
25 Celesti, A., Ruggeri, A., Fazio, M., Galletta, A., Villari, M., & Romano, A. (2020). Blockchain-  
26 based healthcare workflow for tele-medical laboratory in federated hospital IoT  
27 clouds. *Sensors*, 20(9), 2590.

28  
29  
30 Chaubey, A., & Sahoo, C. K. (2021). Assimilation of business intelligence: The effect of  
31 external pressures and top leaders commitment during pandemic crisis. *International Journal*  
32 *of Information Management*, 59, 102344.

33  
34  
35 Choi, T. M. (2021). Fighting against COVID-19: what operations research can help and the  
36 sense-and-respond framework. *Annals of Operations Research*, 1-17.  
37 <https://doi.org/10.1007/s10479-021-03973-w>

38  
39  
40 Choi, T. M., & Sethi, S. (2010). Innovative quick response programs: a review. *International*  
41 *Journal of Production Economics*, 127(1), 1-12.

42  
43 Choudhury, H., Goswami, B., & Gurung, S. K. (2021). CovidChain: an anonymity preserving  
44 blockchain based framework for protection against Covid-19. *Information Security Journal: A*  
45 *Global Perspective*, 1-24. DOI: 10.1080/19393555.2021.1921315.

46  
47  
48 Clapp, J. (2017). Food self-sufficiency: Making sense of it, and when it makes sense. *Food*  
49 *policy*, 66, 88-96.

50  
51  
52 Connell, J., & Lowe, A. (1997). Generating grounded theory from qualitative data: The  
53 application of inductive methods in tourism and hospitality management research. *Progress in*  
54 *Tourism and Hospitality Research*, 3(2), 165-173.

55  
56  
57 Conway, T., & Swift, J. S. (2000). International relationship marketing: The importance of  
58 psychic distance. *European Journal of Marketing*, 34(11/12), 1391–1414.

- 1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65
- Cozzolino, A., Rossi, S., & Conforti, A. (2012). Agile and lean principles in the humanitarian supply chain. *Journal of Humanitarian Logistics and Supply Chain Management*, 2, 16-33.
- Dasaklis, T. K., Pappis, C. P., & Rachaniotis, N. P. (2012). Epidemics control and logistics operations: A review. *International Journal of Production Economics*, 139(2), 393-410.
- Day, J. M., Melnyk, S. A., Larson, P. D., Davis, E. W., & Whybark, D. C. (2012). Humanitarian and disaster relief supply chains: a matter of life and death. *Journal of Supply Chain Management*, 48(2), 21-36.
- de Camargo Fiorini, P., Jabbour, C. J. C., de Sousa Jabbour, A. B. L., & Ramsden, G. (2021). The human side of humanitarian supply chains: a research agenda and systematization framework. *Annals of Operations Research*, 1-26. <https://doi.org/10.1007/s10479-021-03970-z>
- De Rond, M., & Miller, A. N. (2005). Publish or perish: bane or boon of academic life?. *Journal of management inquiry*, 14(4), 321-329.
- DeWitte, S. N. (2014). Mortality risk and survival in the aftermath of the medieval Black Death. *PloS one*, 9(5), e96513.
- Dolinskaya, I., Besiou, M., & Guerrero-Garcia, S. (2018). Humanitarian medical supply chain in disaster response. *Journal of Humanitarian Logistics and Supply Chain Management*, 8(2), 199-226.
- Dondorp, A. M., Hayat, M., Aryal, D., Beane, A., & Schultz, M. J. (2020). Respiratory support in COVID-19 patients, with a focus on resource-limited settings. *The American journal of tropical medicine and hygiene*, 102(6), 1191-1197.
- Dong, Y. M., Sun, J., Li, Y. X., Chen, Q., Liu, Q. Q., Sun, Z., ... & Ye, D. W. (2021). Development and validation of a nomogram for assessing survival in patients with COVID-19 pneumonia. *Clinical Infectious Diseases*, 72(4), 652-660.
- Dror, A. A., Eisenbach, N., Taiber, S., Morozov, N. G., Mizrahi, M., Zigron, A., ... & Sela, E. (2020). Vaccine hesitancy: the next challenge in the fight against COVID-19. *European journal of epidemiology*, 35(8), 775-779.
- Dubey, R., & Gunasekaran, A. (2016). The sustainable humanitarian supply chain design: agility, adaptability and alignment. *International Journal of Logistics Research and Applications*, 19(1), 62-82.
- Dubey, R., Bryde, D. J., Foropon, C., Graham, G., Giannakis, M., & Mishra, D. B. (2020). Agility in humanitarian supply chain: an organizational information processing perspective and relational view. *Annals of Operations Research*, 1-21. <https://doi.org/10.1007/s10479-020-03824-0>
- Dubey, R., Gunasekaran, A., & Papadopoulos, T. (2019a). Disaster relief operations: Past, present and future. *Annals of Operations Research*, 283(1), 1-8.

1 Dubey, R., Gunasekaran, A., Childe, S. J., Roubaud, D., Wamba, S. F., Giannakis, M., &  
2 Foropon, C. (2019b). Big data analytics and organizational culture as complements to swift  
3 trust and collaborative performance in the humanitarian supply chain. *International Journal of*  
4 *Production Economics*, 210, 120-136.

5  
6 Dubey, R., Luo, Z., Gunasekaran, A., Akter, S., Hazen, B. T., & Douglas, M. A. (2018). Big  
7 data and predictive analytics in humanitarian supply chains: Enabling visibility and  
8 coordination in the presence of swift trust. *The International Journal of Logistics Management*,  
9 29(2), 485-512.

10  
11  
12 Dubey, R., Singh, T., & Gupta, O. K. (2015). Impact of agility, adaptability and alignment on  
13 humanitarian logistics performance: mediating effect of leadership. *Global Business*  
14 *Review*, 16(5), 812-831.

15  
16  
17 Duran, S., Gutierrez, M. A., & Keskinocak, P. (2011). Pre-positioning of emergency items for  
18 CARE international. *Interfaces*, 41(3), 223-237.

19  
20  
21 Eisenstadt, M., Ramachandran, M., Chowdhury, N., Third, A., & Domingue, J. (2020).  
22 COVID-19 antibody test/vaccination certification: there's an app for that. *IEEE Open Journal*  
23 *of Engineering in Medicine and Biology*, 1, 148-155.

24  
25  
26 Ergun, Ö., Gui, L., HeierStamm, J. L., Keskinocak, P., & Swann, J. (2014). Improving  
27 humanitarian operations through technology-enabled collaboration. *Production and Operations*  
28 *Management*, 23(6), 1002–1014.

29  
30  
31 Esbin, M. N., Whitney, O. N., Chong, S., Maurer, A., Darzacq, X., & Tjian, R. (2020).  
32 Overcoming the bottleneck to widespread testing: a rapid review of nucleic acid testing  
33 approaches for COVID-19 detection. *Rna*, 26(7), 771-783.

34  
35  
36 Farooq, M. U., Hussain, A., Masood, T., & Habib, M. S. (2021). Supply chain operations  
37 management in pandemics: a state-of-the-art review inspired by COVID-  
38 19. *Sustainability*, 13(5), 2504.

39  
40  
41 Forman, R., Shah, S., Jeurissen, P., Jit, M., & Mossialos, E. (2021). COVID-19 vaccine  
42 challenges: What have we learned so far and what remains to be done? *Health Policy*, 125,  
43 553-567.

44  
45  
46 Friday, D., Savage, D. A., Melnyk, S. A., Harrison, N., Ryan, S., & Wechtler, H. (2021). A  
47 collaborative approach to maintaining optimal inventory and mitigating stockout risks during  
48 a pandemic: capabilities for enabling health-care supply chain resilience. *Journal of*  
49 *Humanitarian Logistics and Supply Chain Management*, 11(2), 248-271.

50  
51  
52  
53 Garg, C., Bansal, A., & Padappayil, R. P. (2020). COVID-19: prolonged social distancing  
54 implementation strategy using blockchain-based movement passes. *Journal of Medical*  
55 *Systems*, 44(9), 1-3.

- 1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65
- Gatignon, A., Van Wassenhove, L. N., & Charles, A. (2010). The Yogyakarta earthquake: Humanitarian relief through IFRC's decentralized supply chain. *International Journal of Production Economics*, 126(1), 102-110.
- Gunasekaran, A., & Ngai, E. W. T. (2003). The successful management of a small logistics company. *International Journal of Physical Distribution and Logistics Management*, 33(9), 825–842.
- Gupta, M., Shoja, A., & Mikalef, P. (2021). Toward the understanding of national culture in the success of non- pharmaceutical technological interventions in mitigating COVID-19 pandemic. *Annals of Operations Research*, 1-18.
- Gutierrez, D., Sinskey, A. J., & Springs, S. L. (2021). Modeling Framework to Evaluate Vaccine Strategies against the COVID-19 Pandemic. *Systems*, 9(1), 4.
- Hantoko, D., Li, X., Pariatamby, A., Yoshikawa, K., Horttanainen, M., & Yan, M. (2021). Challenges and practices on waste management and disposal during COVID-19 pandemic. *Journal of Environmental Management*, 286, 112140.
- Haque, M., & Islam, R. (2018). Impact of supply chain collaboration and knowledge sharing on organizational outcomes in pharmaceutical industry of Bangladesh. *Journal of Global Operations and Strategic Sourcing*, 11, 301-320.
- Harpring, R., Maghsoudi, A., Fikar, C., Piotrowicz, W. D., & Heaslip, G. (2021). An analysis of compounding factors of epidemics in complex emergencies: a system dynamics approach. *Journal of Humanitarian Logistics and Supply Chain Management*, 11(2), 198-226.
- Herlin, H., & Pazirandeh, A. (2015). Avoiding the pitfalls of cooperative purchasing through control and coordination: Insights from a humanitarian context. *International Journal of Procurement Management*, 8(3), 303-325.
- Hippold, S. (2020). Coronavirus: How to secure your supply chain. [https://www.gartner.com/smarter with gartner/coronavirus how-to-secure-your-supply-chain/](https://www.gartner.com/smarter-with-gartner/coronavirus-how-to-secure-your-supply-chain/). Accessed on May 24, 2021.
- Hocutt, M. A. (1998). Relationship dissolution model: Antecedents of relationship commitment and the likelihood of dissolving a relationship. *International Journal of Service Industry Management*, 9(2), 189–200.
- Iakovou, E., Vlachos, D., Keramydas, C., & Partsch, D. (2014). Dual sourcing for mitigating humanitarian supply chain disruptions. *Journal of Humanitarian Logistics and Supply Chain Management*, 4(2), 245-264.
- Ivanov, D. (2020a). Viable supply chain model: integrating agility, resilience and sustainability perspectives—lessons from and thinking beyond the COVID-19 pandemic. *Annals of Operations Research*, 1-21. <https://doi.org/10.1007/s10479-020-03640-6>
- Ivanov, D. (2020b). Predicting the impacts of epidemic outbreaks on global supply chains: A simulation-based analysis on the coronavirus outbreak (COVID-19/SARS-CoV-2) case. *Transportation Research Part E: Logistics and Transportation Review*, 136, 101922.

1 Ivanov, D. (2021). Exiting the COVID-19 pandemic: after-shock risks and avoidance of  
2 disruption tails in supply chains. *Annals of Operations Research*, 1-18.  
3 <https://doi.org/10.1007/s10479-021-04047-7>

4 Ivanov, D., & Dolgui, A. (2021). OR-methods for coping with the ripple effect in supply chains  
5 during COVID-19 pandemic: Managerial insights and research implications. *International*  
6 *Journal of Production Economics*, 232, 107921.

7 Jabbarzadeh, A., Haughton, M., & Pourmehdi, F. (2019). A robust optimization model for  
8 efficient and green supply chain planning with postponement strategy. *International Journal*  
9 *of Production Economics*, 214, 266-283.

10 Jabbour, C. J. C., Sobreiro, V. A., de Sousa Jabbour, A. B. L., de Souza Campos, L. M.,  
11 Mariano, E. B., & Renwick, D. W. S. (2019). An analysis of the literature on humanitarian  
12 logistics and supply chain management: Paving the way for future studies. *Annals of*  
13 *Operations Research*, 283, 289–307.

14 Jahre, M. (2017). Humanitarian supply chain strategies—a review of how actors mitigate supply  
15 chain risks. *Journal of Humanitarian Logistics and Supply Chain Management*, 7(2), 82-101.

16 Javid, M., & Khan, I. H. (2021). Internet of Things (IoT) enabled healthcare helps to take the  
17 challenges of COVID-19 Pandemic. *Journal of Oral Biology and Craniofacial*  
18 *Research*, 11(2), 209-214.

19 Jin, S., Jeong, S., Kim, J., & Kim, K. (2015). A logistics model for the transport of disaster  
20 victims with various injuries and survival probabilities. *Annals of Operations Research*, 230(1),  
21 17–33.

22 Kabra, G., & Ramesh, A. (2015). Analyzing drivers and barriers of coordination in  
23 humanitarian supply chain management under fuzzy environment. *Benchmarking: An*  
24 *International Journal*, 22(4), 559–587.

25 Karthik, K., Babu, R. P. A., Dhama, K., Chitra, M. A., Kalaiselvi, G., Senthil kumar, T. M. A.,  
26 & Raj, G. D. (2020). Biosafety Concerns During the Collection, Transportation, and Processing  
27 of COVID-19 Samples for Diagnosis. *Archives of Medical Research*.

28 Karuppiah, K., Sankaranarayanan, B., Ali, S. M., & Paul, S. K. (2021). Key Challenges to  
29 Sustainable Humanitarian Supply Chains: Lessons from the COVID-19  
30 Pandemic. *Sustainability*, 13(11), 5850.

31 Khatoon, A. (2020). Use of blockchain technology to curb Novel Coronavirus Disease  
32 (COVID-19) transmission. *Available at SSRN 3584226*.

33 Kim, J. H., Marks, F., & Clemens, J. D. (2021). Looking beyond COVID-19 vaccine phase 3  
34 trials. *Nature medicine*, 27(2), 205-211.

35 Klueber, R., & O’Keefe, R. M. (2013). Defining and assessing requisite supply chain visibility  
36 in regulated industries. *Journal of Enterprise Information Management*, 26(3), 295-313.

1 Kovács, G., & Falagara Sigala, I. (2021). Lessons learned from humanitarian logistics to  
2 manage supply chain disruptions. *Journal of Supply Chain Management*, 57(1), 41-49.

3 Kovács, G., & Spens, K. M. (2007). Humanitarian logistics in disaster relief  
4 operations. *International journal of physical distribution & logistics management*, 37(2), 99-  
5 114.  
6

7  
8 Kumar, A. (2020). Improvement of public distribution system efficiency applying blockchain  
9 technology during pandemic outbreak (COVID-19). *Journal of Humanitarian Logistics and*  
10 *Supply Chain Management*, 11(1), 1-28.

11  
12  
13 Kumar, A., Singh, R. K., & Modgil, S. (2020b). Exploring the relationship between ICT, SCM  
14 practices and organizational performance in agri-food supply chain. *Benchmarking: An*  
15 *International Journal*, 27(3), 1003-1041.  
16  
17

18  
19 Kumar, M. S., Raut, R. D., Narwane, V. S., & Narkhede, B. E. (2020a). Applications of  
20 industry 4.0 to overcome the COVID-19 operational challenges. *Diabetes & Metabolic*  
21 *Syndrome: Clinical Research & Reviews*, 14(5), 1283-1289.  
22  
23

24  
25 Kumar, P., & Singh, R. K (2021a). Strategic framework for developing resilience in Agri-Food  
26 Supply Chains during COVID 19 pandemic. *International Journal of Logistics Research and*  
27 *Applications*, 1-24. <https://doi.org/10.1080/13675567.2021.1908524>  
28

29  
30 Kumar, P., & Singh, R. K. (2021b). Application of Industry 4.0 technologies for effective  
31 coordination in humanitarian supply chains: a strategic approach. *Annals of Operations*  
32 *Research*, 1-33. <https://doi.org/10.1007%2Fs10479-020-03898-w>  
33  
34

35  
36 Kumar, S., Xu, C., Ghildayal, N., Chandra, C., & Yang, M. (2021). Social media effectiveness  
37 as a humanitarian response to mitigate influenza epidemic and COVID-19 pandemic. *Annals*  
38 *of Operations Research*, 1-29. <https://doi.org/10.1007/s10479-021-03955-y>  
39

40  
41 Kunz, N., & Reiner, G. (2012). A meta- analysis of humanitarian logistics research. *Journal*  
42 *of Humanitarian Logistics and Supply Chain Management*, 2(2), 116-147.

43  
44 Laborde, D., Martin, W., & Vos, R. (2020). Poverty and food insecurity could grow  
45 dramatically as COVID-19 spreads. *International Food Policy Research Institute (IFPRI)*,  
46 *Washington, DC*.  
47 [https://www.researchgate.net/profile/Rob\\_Vos2/publication/343267777\\_Poverty\\_and\\_food\\_insecurity\\_could\\_grow\\_dramatically\\_as\\_COVID-19\\_spreads/links/5f20772345851515ef509bf7/Poverty-and-food-insecurity-could-grow-dramatically-as-COVID-19-spreads.pdf](https://www.researchgate.net/profile/Rob_Vos2/publication/343267777_Poverty_and_food_insecurity_could_grow_dramatically_as_COVID-19_spreads/links/5f20772345851515ef509bf7/Poverty-and-food-insecurity-could-grow-dramatically-as-COVID-19-spreads.pdf)  
48  
49  
50  
51  
52

53  
54 Lancet, T. (2020). COVID-19: too little, too late?. *Lancet (London, England)*, 395(10226),  
55 755.  
56

57  
58 Mallett, S., Allen, A. J., Graziadio, S., Taylor, S. A., Sakai, N. S., Green, K., ... & Halligan, S.  
59 (2020). At what times during infection is SARS-CoV-2 detectable and no longer detectable  
60  
61

1 using RT-PCR-based tests? A systematic review of individual participant data. *BMC*  
2 *medicine*, 18(1), 1-17.

3 Malmir, B., & Zobel, C. W. (2021). An applied approach to multi-criteria humanitarian supply  
4 chain planning for pandemic response. *Journal of Humanitarian Logistics and Supply Chain*  
5 *Management*, 11(2), 320-346.

6  
7  
8 Mandal, S., & Dubey, R. K. (2021). Effect of inter-organizational systems appropriation in  
9 agility and resilience development: an empirical investigation. *Benchmarking: An*  
10 *International Journal*, <https://doi.org/10.1108/BIJ-10-2020-0542>

11  
12  
13 Mandal, S., & Dubey, R. K. (2021). Effect of inter-organizational systems appropriation in  
14 agility and resilience development: an empirical investigation. *Benchmarking: An*  
15 *International Journal*, <https://doi.org/10.1108/BIJ-10-2020-0542>

16  
17  
18 Marbouh, D., Abbasi, T., Maasmi, F., Omar, I. A., Debe, M. S., Salah, K., ... & Ellahham, S.  
19 (2020). Blockchain for COVID-19: Review, Opportunities, and a Trusted Tracking  
20 System. *Arabian Journal for Science and Engineering*, 45:9895–9911.

21  
22  
23 Marić, J., Galera-Zarco, C., & Opazo-Basáez, M. (2021). The emergent role of digital  
24 technologies in the context of humanitarian supply chains: a systematic literature  
25 review. *Annals of Operations Research*, 1-42.

26  
27  
28 Martin, D., & Woodside, A. G. (2008). Grounded theory of international tourism  
29 behavior. *Journal of Travel & Tourism Marketing*, 24(4), 245-258.

30  
31  
32 Meyerson, D., Weick, K.E., & Kramer, R.M.(1996). Swift trust and temporary groups. In R.M.  
33 Kramer and T.R. Tyler (eds.), *Trust in Organizations: Frontiers of Theory and Research*.  
34 Thousand Oaks, CA: Sage, pp. 166–195.

35  
36  
37 Miettila, A., & Moller, K. (1990). Interaction perspective into professional business services:  
38 A conceptual analysis. In R. Fiocca & I. Snehota (Eds.), *IMP conference: Research*  
39 *developments in international industrial marketing and purchasing* (6th ed., pp. 759–781).  
40 Milan: University of Bocconi.

41  
42  
43 Mobula, L. M., Samaha, H., Yao, M., Gueye, A. S., Diallo, B., Umutoni, C., ... & Ahuka-  
44 Mundeke, S. (2020). Recommendations for the COVID-19 response at the national level based  
45 on lessons learned from the Ebola virus disease outbreak in the Democratic Republic of the  
46 Congo. *The American journal of tropical medicine and hygiene*, 103(1), 12-17.

47  
48  
49 Mordechai, L., Eisenberg, M., Newfield, T. P., Izdebski, A., Kay, J. E., & Poinar, H. (2019).  
50 The Justinianic Plague: an inconsequential pandemic?. *Proceedings of the National Academy*  
51 *of Sciences*, 116(51), 25546-25554.

52  
53  
54  
55 Narwane, V. S., Raut, R. D., Mangla, S. K., Gardas, B. B., Narkhede, B. E., Awasthi, A., &  
56 Priyadarshinee, P. (2020). Mediating role of cloud of things in improving performance of small  
57 and medium enterprises in the Indian context. *Annals of Operations Research*, 1-30.  
58 <https://doi.org/10.1007/s10479-019-03502-w>

- 1  
2  
3  
4  
5  
6  
7  
8  
9  
10  
11  
12  
13  
14  
15  
16  
17  
18  
19  
20  
21  
22  
23  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65
- Nematollahi, M., Hosseini-Motlagh, S. M., Ignatius, J., Goh, M., & Nia, M. S. (2018). Coordinating a socially responsible pharmaceutical supply chain under periodic review replenishment policies. *Journal of Cleaner Production*, *172*, 2876-2891.
- Nunkoo, R., & Ramkissoon, H. (2016). Stakeholders' views of enclave tourism: A grounded theory approach. *Journal of Hospitality & Tourism Research*, *40*(5), 557-558.
- Nzediegwu, C., & Chang, S. X. (2020). Improper solid waste management increases potential for COVID-19 spread in developing countries. *Resources, conservation, and recycling*, *161*, 104947.
- Ocampo, L., & Yamagishi, K. (2020). Modeling the lockdown relaxation protocols of the Philippine government in response to the COVID-19 pandemic: An intuitionistic fuzzy DEMATEL analysis. *Socio-economic planning sciences*, *72*, 100911.
- Opit, P. F., & Nakade, K. (2015, December). Emergency response model of stock-prepositioning with transportation constraints. In *2015 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)* (pp. 239-243). IEEE.
- Ornstein, K. A., Leff, B., Covinsky, K. E., Ritchie, C. S., Federman, A. D., Roberts, L., ... & Szanton, S. L. (2015). Epidemiology of the homebound population in the United States. *JAMA internal medicine*, *175*(7), 1180-1186.
- Panahifar, F., Heavey, C., Byrne, P. J., & Fazlollahtabar, H. (2015). A framework for collaborative planning, forecasting and replenishment (CPFR). *Journal of Enterprise Information Management*. [http://doras.dcu.ie/20876/1/IEIM\\_2015\\_-\\_CPFR-State-of-the-Art.pdf](http://doras.dcu.ie/20876/1/IEIM_2015_-_CPFR-State-of-the-Art.pdf)
- Pandey, A., & Galvani, A. P. (2019). The global burden of HIV and prospects for control. *The Lancet HIV*, *6*(12), e809-e811.
- Peng, J., Wu, X., Wang, R., Li, C., Zhang, Q., & Wei, D. (2020). Medical waste management practice during the 2019-2020 novel coronavirus pandemic: Experience in a general hospital. *American journal of infection control*, *48*(8), 918-921.
- Pingali, P., Mitra, B., & Rahman, A. (2017). The bumpy road from food to nutrition security—Slow evolution of India's food policy. *Global food security*, *15*, 77-84.
- Pisano, G. P., Sadun, R., & Zanini, M. (2020). Lessons from Italy's response to coronavirus. *Harvard Business Review*, *27*. <https://fondazionecerm.it/wp-content/uploads/2020/04/HBR-Lessons-from-Italy%E2%80%99s-Response-to-Coronavirus.pdf>. Accessed on June 27, 2021.
- Pogue, K., Jensen, J. L., Stancil, C. K., Ferguson, D. G., Hughes, S. J., Mello, E. J., ... & Poole, B. D. (2020). Influences on attitudes regarding potential COVID-19 vaccination in the United States. *Vaccines*, *8*(4), 582.

1 Queiroz, M. M., & Fosso Wamba, S. (2021). A structured literature review on the interplay  
2 between emerging technologies and COVID-19—insights and directions to operations  
3 fields. *Annals of Operations Research*, 1-27. <https://doi.org/10.1007/s10479-021-04107-y>

4 Queiroz, M. M., Ivanov, D., Dolgui, A., & Wamba, S. F. (2020). Impacts of epidemic outbreaks  
5 on supply chains: mapping a research agenda amid the COVID-19 pandemic through a  
6 structured literature review. *Annals of operations research*, 1-38. DOI  
7 <https://doi.org/10.1007/s10479-020-03685-7>

8 Ramirez Lopez, L. J., & Beltrán Álvarez, N. (2020). Blockchain application in the distribution  
9 chain of the COVID-19 vaccine: a designing understudy. *Advance* 14 (2) (2020) 1–9,  
10 doi:10.31124/advance.12274844.v1.

11 Reardon, T., Echeverria, R., Berdegué, J., Minten, B., Liverpool-Tasie, S., Tschirley, D., &  
12 Zilberman, D. (2019). Rapid transformation of food systems in developing regions:  
13 highlighting the role of agricultural research & innovations. *Agricultural systems*, 172, 47-59.

14 Rele, S. (2021). COVID-19 vaccine development during pandemic: Gap analysis,  
15 opportunities, and impact on future emerging infectious disease development  
16 strategies. *Human Vaccines & Immunotherapeutics*, 17(4), 1122-1127.

17 Ritchie, C. S., Gallopyn, N., Sheehan, O., Sharieff, S. A., Franzosa, E., Gorbenko, K., ... &  
18 Leff, B. (2021). COVID Challenges and Adaptations Among Home-Based Primary Care  
19 Practices: Lessons for an Ongoing Pandemic From a National Survey. *Journal of the American*  
20 *Medical Directors Association*. Doi: 10.1016/j.jamda.2021.05.016.

21 Rustam, F., Reshi, A. A., Mehmood, A., Ullah, S., On, B. W., Aslam, W., & Choi, G. S. (2020).  
22 COVID-19 future forecasting using supervised machine learning models. *IEEE access*, 8,  
23 101489-101499.

24 Sabri, Y.; Zarei, M.H.; Harland, C. (2019). Using collaborative research methodologies in  
25 humanitarian supply chains. *Journal of Humanitarian Logistics and Supply Chain*  
26 *Management*, 9, 371–409

27 Saleh, F. I. M., & Karia, N. (2020). Benchmarks for INGOs' effective responses during  
28 COVID-19 pandemic. *Benchmarking: An International Journal*, 27(10), 28-63-2886.

29 Schoch-Spana, M., Brunson, E. K., Long, R., Ruth, A., Ravi, S. J., Trotochaud, M., ... & White,  
30 A. (2020). The public's role in COVID-19 vaccination: Human-centered recommendations to  
31 enhance pandemic vaccine awareness, access, and acceptance in the United States. *Vaccine*.  
32 <https://doi.org/10.1016/j.vaccine.2020.10.059>

33 Schulz, S. F., & Blecken, A. (2010). Horizontal cooperation in disaster relief logistics: benefits  
34 and impediments. *International Journal of Physical Distribution & Logistics Management*,  
35 40(8/9), 636-656.

- 1 Sharifi-Sedeh, M., Ardalan, A., Torabi, S. A., & Khorasani-Zavareh, D. (2020). Factors behind  
2 the prepositioning of relief items in Iran: a qualitative study. *Injury*, 51(4), 906-912.
- 3 Sigala, I. F., Kettinger, W. J., & Wakolbinger, T. (2020). Digitizing the field: designing ERP  
4 systems for Triple-A humanitarian supply chains. *Journal of Humanitarian Logistics and*  
5 *Supply Chain Management*, 10(2), 231-260.
- 6  
7  
8 Singh, K., & Mehta, S. (2016). The clinical development process for a novel preventive  
9 vaccine: An overview. *Journal of postgraduate medicine*, 62(1), 4.
- 10  
11 Singh, R. K., Gupta, A., & Gunasekaran, A. (2018). Analysing the interaction of factors for  
12 resilient humanitarian supply chain. *International Journal of Production Research*, 56(21),  
13 6809-6827.
- 14  
15  
16 Singh, S., Kumar, R., Panchal, R., & Tiwari, M. K. (2021). Impact of COVID-19 on logistics  
17 systems and disruptions in food supply chain. *International Journal of Production*  
18 *Research*, 59(7), 1993-2008.
- 19  
20  
21 Sokat, K. Y., & Altay, N. (2021). Serving vulnerable populations under the threat of epidemics  
22 and pandemics. *Journal of Humanitarian Logistics and Supply Chain Management*. DOI  
23 10.1108/JHLSCM-08-2020-0070.
- 24  
25  
26 Stall, N., Nowaczynski, M., & Sinha, S. K. (2014). Systematic review of outcomes from  
27 home- based primary care programs for homebound older adults. *Journal of the American*  
28 *Geriatrics Society*, 62(12), 2243-2251.
- 29  
30  
31 Tareq, M. S., Rahman, T., Hossain, M., & Dorrington, P. (2021). Additive manufacturing and  
32 the COVID-19 challenges: An in-depth study. *Journal of Manufacturing Systems*.  
33 <https://doi.org/10.1016/j.jmsy.2020.12.021>
- 34  
35  
36 Tatham, P., & Kovács, G. (2007). The humanitarian supply network in rapid onset disasters.  
37 In Proceedings of the 19th annual conference for Nordic researchers in logistics,  
38 NOFOMA (pp. 1059–1074).
- 39  
40  
41 Thomas, A. S., & Kopczak, L. R. (2005). From logistics to supply chain management: the path  
42 forward in the humanitarian sector. *Fritz Institute*, 15(1), 1-15.
- 43  
44  
45 Thompson, D. D., & Anderson, R. (2021). The COVID-19 response: considerations for future  
46 humanitarian supply chain and logistics management research. *Journal of Humanitarian*  
47 *Logistics and Supply Chain Management*. DOI 10.1108/JHLSCM-01-2021-0006
- 48  
49  
50 Thompson, D., & Lei, Y. (2020). Mini review: Recent progress in RT-LAMP enabled COVID-  
51 19 detection. *Sensors and Actuators Reports*, 100017.
- 52  
53  
54 Tomasini, R. M., & Van Wassenhove, L. N. (2009). From preparedness to partnerships: case  
55 study research on humanitarian logistics. *International Transactions in operational*  
56 *research*, 16(5), 549-559.
- 57  
58  
59  
60  
61  
62  
63  
64  
65

1 Torabi, S. A., Shokr, I., Tofighi, S., & Heydari, J. (2018). Integrated relief pre-positioning and  
2 procurement planning in humanitarian supply chains. *Transportation Research Part E:  
3 Logistics and Transportation Review*, 113, 123-146.

4 Totten, A. M., White-Chu, E. F., Wasson, N., Morgan, E., Kansagara, D., Davis-O'Reilly, C.,  
5 & Goodlin, S. (2016). Home-Based Primary Care Interventions.(Prepared by the Pacific  
6 Northwest Evidence-Based Practice Center Under Contract No 290-2012-00014-I) AHRQ  
7 Publication No 15 (16)-EHC036-EF. Rockville: Agency for Healthcare Research and Quality;  
8 2016. *Rockville, MD: Agency for Healthcare Research and Quality*.

9 Toyasaki, F., Arikan, E., Silbermayr, L., & Falagara Sigala, I. (2017). Disaster relief inventory  
10 management: Horizontal cooperation between humanitarian organizations. *Production and  
11 Operations Management*, 26(6), 1221-1237.

12 Van der Laan, E., van Dalen, J., Rohrmoser, M., & Simpson, R. (2016). Demand forecasting  
13 and order planning for humanitarian logistics: An empirical assessment. *Journal of Operations  
14 Management*, 45, 114-122.

15 Van Wassenhove, L. N. (2006). Humanitarian aid logistics: supply chain management in high  
16 gear. *Journal of the Operational research Society*, 57(5), 475-489.

17 Vega, D. (2018). Case studies in humanitarian logistics research. *Journal of Humanitarian  
18 Logistics and Supply Chain Management*, 8, 134–152.

19 Villa, S., Lombardi, A., Mangioni, D., Bozzi, G., Bandera, A., Gori, A., & Raviglione, M. C.  
20 (2020). The COVID-19 pandemic preparedness or lack thereof: from China to Italy. *Global  
21 Health & Medicine*. DOI: 10.35772/ghm.2020.01016.

22 Wang, J., Shen, J., Ye, D., Yan, X., Zhang, Y., Yang, W., ... & Pan, L. (2020). Disinfection  
23 technology of hospital wastes and wastewater: Suggestions for disinfection strategy during  
24 coronavirus Disease 2019 (COVID-19) pandemic in China. *Environmental pollution*, 114665.

25 Warren, G. W., & Lofstedt, R. (2021). COVID-19 vaccine rollout risk communication  
26 strategies in Europe: a rapid response. *Journal of Risk Research*, 24(3/4), 369-379.

27 Whitten, G. D., Green, K. W., & Zelbst, P. J. (2012). Triple- A supply chain  
28 performance. *International Journal of Operations & Production Management*, 32(1), 28-48.

29 Wilson, D. T. (1995). An integrated model of buyer-seller relationships. *Journal of the  
30 Academy of Marketing Science*, 23(4), 335–345.

31 Wise, J. (2021). Covid-19: Countries rally to support India through “storm that has shaken the  
32 nation”. *BMJ: British Medical Journal (Online)*, 373.

33 Wolfswinkel, J. F., Furtmueller, E., & Wilderom, C. P. (2013). Using grounded theory as a  
34 method for rigorously reviewing literature. *European journal of information systems*, 22(1),  
35 45-55.

Worldometer (2021). Countries where COVID-19 has spread. <https://www.worldometers.info/coronavirus/countries-where-coronavirus-has-spread/>  
Accessed on August 30, 2021.

Xu, G., Feng, Z., Wu, H., & Zhao, D. (2007). Swift trust in a virtual temporary system: A model based on the Dempster–Shafer theory of belief functions. *International Journal of Electronic Commerce*, 12(1), 93–126.

Xu, H., Zhang, L., Onireti, O., Fang, Y., Buchanan, W. J., & Imran, M. A. (2020). BeepTrace: blockchain-enabled privacy-preserving contact tracing for COVID-19 pandemic and beyond. *IEEE Internet of Things Journal*. : DOI 10.1109/JIOT.2020.3025953.

Yang, J., Xie, H., Yu, G., & Liu, M. (2021). Antecedents and consequences of supply chain risk management capabilities: An investigation in the post-coronavirus crisis. *International Journal of Production Research*, 59(5), 1573-1585.

Yang, Q., Wang, Q., & Zhao, X. (2019). A taxonomy of transaction-specific investments and its effects on cooperation in logistics outsourcing relationships. *International Journal of Logistics Research and Applications*, 22(6), 557-575.

Yapjajakis, C. (2009). Hippocrates of Kos, the father of clinical medicine, and Asclepiades of Bithynia, the father of molecular medicine. *in vivo*, 23(4), 507-514.

Yu, Y., Li, Y., Zhang, Z., Gu, Z., Zhong, H., Zha, Q., ... & Chen, E. (2020). A bibliometric analysis using VOSviewer of publications on COVID-19. *Annals of translational medicine*, 8(13), 816. doi: [10.21037/atm-20-4235](https://doi.org/10.21037/atm-20-4235)

Zheng, L., Xiao, C., Chen, F., & Xiao, Y. (2020). Design and research of a smart monitoring system for 2019-nCoV infection-contact isolated people based on blockchain and Internet of things technology. *Research Square* 12 (1) (2020) 1–11. Doi:10.21203/rs.3.rs-18678/v1.

Zolin, R. (2002). Swift trust in hastily formed networks, The Hastily Formed Networks Research Group, Monterey, CA. <http://www.nps.edu/Cebrowski/Docs/swiftrust100302.pdf>.

## Appendix A: List of papers considered for the review process

| S. No. | Title   | References            | Journal                              |
|--------|---|-----------------------|--------------------------------------|
| 1.     | Impacts of epidemic outbreaks on supply chains: mapping a research agenda amid the COVID-19 pandemic through a structured literature review | Queiroz et al. (2020) | <i>Annals of Operations Research</i> |
| 2.     | Social media effectiveness as a humanitarian response to mitigate influenza epidemic and COVID-19 pandemic                                  | Kumar et al. (2021)   |                                      |
| 3.     | Toward the understanding of national culture in the success of non- pharmaceutical  | Gupta et al. (2021)   |                                      |

1 technological interventions in mitigating the  
2 COVID-19 pandemic

- 3 4. Data laboratory for supply chain response Anparasan, and  
4 models during epidemic outbreaks Lejeune (2018)  
5 5. Viable supply chain model: integrating agility, Ivanov (2020a)  
6 resilience and sustainability perspectives—  
7 lessons from and thinking beyond the COVID-  
8 19 pandemic  
9 6. Exiting the COVID-19 pandemic: after-shock Ivanov (2021)  
10 risks and avoidance of disruption tails in supply  
11 chains  
12 7. Stopping Covid-19: A pandemic-management Baveja et al.  
13 service value chain approach (2020)  
14 8. Agility in the humanitarian supply chain: an Dubey et al.  
15 organizational information processing (2020)  
16 perspective and relational view  
17 9. Disaster relief operations: Past, present, and Dubey et al.  
18 future (2019a)  
19 10. Fighting against COVID-19: what operations Choi (2021)  
20 research can help and the sense-and-respond  
21 framework  
22 11. A structured literature review on the interplay Queiroz and Fosso  
23 between emerging technologies and COVID- Wamba (2021)  
24 19—insights and directions to operations fields  
25 12. The human side of humanitarian supply chains: de Camargo  
26 a research agenda and systematization Fiorini et al.  
27 framework (2021)  
28 13. An analysis of the literature on humanitarian Jabbour et al.  
29 logistics and supply chain management: Paving (2019)  
30 the way for future studies  
31 14. Application of Industry 4.0 technologies for Kumar and Singh  
32 effective coordination in humanitarian supply (2021b)  
33 chains: a strategic approach  
34 15. The emergent role of digital technologies in the Marić et al. (2021)  
35 context of humanitarian supply chains: a  
36 systematic literature review
- 
- 37 16. An applied approach to multi-criteria Malmir and Zobel  
38 humanitarian supply chain planning for (2021)  
39 pandemic response  
40 17. Serving vulnerable populations under the threat Sokat and Altay  
41 of epidemics and pandemics (2021)  
42 18. The COVID-19 epidemic and evaluating the Allahi et al.  
43 corresponding responses to crisis management (2021)  
44 in refugees: a system dynamic approach  
45 19. A collaborative approach to maintaining optimal Friday et al.  
46 inventory and mitigating stockout risks during a (2021)  
47 pandemic: capabilities for enabling healthcare  
48 supply chain resilience  
49 20. An analysis of compounding factors of Harpring et al.  
50 epidemics in complex emergencies: a system (2021)  
51 dynamics approach.  
52 21. The COVID-19 response: considerations for Thompson and  
53 future humanitarian supply chain and logistics Anderson (2021)  
54 management research  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65

**Journal of  
Humanitarian  
Logistics and  
Supply chain  
Management**

|     |   |  |  |
|-----|---|--|--|
| 22. | Deciding between cash-based and in-kind distributions during humanitarian emergencies   | Castillo (2021)                        |  |
| 23. | Humanitarian medical supply chain in disaster response  | Dolinskaya, and Guerrero-Garcia (2018) |  |
| 24. | Improvement of public distribution system efficiency applying blockchain technology during pandemic outbreak (COVID-19)               | Kumar (2020)                           |  |
| 25. | Analyzing the response to epidemics: concept of evidence-based Haddon matrix  | Anparasan, and Lejeune (2017)          |  |
| 26. | Coordination in humanitarian relief chains: chain coordinators  | Akhtar et al. (2012)                   |  |
| 27. | Dual sourcing for mitigating humanitarian supply chain disruptions  | Iakovou et al. (2014)                  |  |
| 28. | Humanitarian supply chain strategies—a review of how actors mitigate supply chain risks   | Jahre (2017)                           |  |
| 29. | A meta- analysis of humanitarian logistics research.  | Kunz and Reiner (2012)                 |  |
| 30. | Digitizing the field: designing ERP systems for Triple-A humanitarian supply chains.  | Sigala et al. (2020)                   |  |
| 31. | Effect of inter-organizational systems appropriation in agility and resilience development: an empirical investigation                | Mandal and Dubey (2021)                | <b>Benchmarking: An international Journal</b>          |
| 32. | Analyzing drivers and barriers of coordination in humanitarian supply chain management under fuzzy environment                        | Kabra and Ramesh (2015)                |  |
| 33. | Benchmarks for INGOs' effective responses during COVID-19 pandemic  | Saleh and Karia (2020)                 |  |
| 34. | OR-methods for coping with the ripple effect in supply chains during COVID-19 pandemic: Managerial insights and research implications | Ivanov and Dolgui (2021).              | <b>International Journal of Production Economics</b>   |
| 35. | Challenges to COVID-19 vaccine supply chain: Implications for sustainable development goals   | Alam et al. (2021)                     |  |
| 36. | Epidemics control and logistics operations: A review  | Dasaklis, et al. (2012)                |  |
| 37. | Antecedents and consequences of supply chain risk management capabilities: An investigation in the post-coronavirus crisis            | Yang et l. (2021)                      | <b>International Journal of Production Research</b>    |
| 38. | Analysing the interaction of factors for resilient humanitarian supply chain  | Singh et al. (2018)                    |  |
| 39. | Impact of COVID-19 on logistics systems and disruptions in food supply chain  | Singh et al. (2021)                    |  |
| 40. | Assimilation of business intelligence: The effect of external pressures and top leaders commitment during pandemic crisis             | Chaubey and Sahoo. (2021).             | <b>International Journal of Information Management</b> |

|     |  |                          |  |
|-----|--|--------------------------|--|
| 41. | Lessons learned from humanitarian logistics to manage supply chain disruptions   | Kovács and Sigala (2021) | <i>Journal of Supply Chain Management</i>                                  |
| 42. | Humanitarian and disaster relief supply chains: a matter of life and death   | Day et al. (2012)        |  |
| 43. | Designing an integrated pharmaceutical relief chain network under demand uncertainty   | Akbarpour et al. (2020)  | <i>Transportation Research Part E: Logistics and Transportation Review</i> |
| 44. | Predicting the impacts of epidemic outbreaks on global supply chains: A simulation-based analysis on the coronavirus outbreak (COVID-19/SARS-CoV-2) case | Ivanov (2020b)           |  |
| 45. | Integrated relief pre-positioning and procurement planning in humanitarian supply chains   | Torabi et al. (2018)     |  |
| 46. | A bibliometric analysis using VOSviewer of publications on COVID-19  | Yu et al. (2020)         | <i>Annals of Transnational Medicine</i>                                    |

## Appendix B: Newspaper, news releases, and technical reports considered for review

Acharjee, S. (May 10, 2021) India's covid collapse, part 4: How the delay in test results accelerated spread of the virus. <https://www.indiatoday.in/magazine/cover-story/story/20210517-india-s-covid-collapse-part-4-how-the-delay-in-test-results-accelerated-spread-of-the-virus-1800972-2021-05-10>.

CBS News (2020a). The Links in the PPE supply chain ‘Have Been Broken’ as hospitals battle coronavirus, CBS News, April 8, available at: <https://www.cbsnews.com/news/coronavirus-ppesupply-chain-hospitals/>.

CBS News (2020b), “Americans face COVID-19 test delays as virus surges: ‘A Hot Mess’”, CBS News, Jul 9, available at: [https://www.cbsnews.com/news/COVID\\_19-testing-delays-results-surge/](https://www.cbsnews.com/news/COVID_19-testing-delays-results-surge/).

Doyle, K. (2020), “‘Inexcusable’: Mick Mulvaney pans coronavirus testing delays”, Washington Examiner, July 13, available at: <https://www.washingtonexaminer.com/news/inexcusablemulvaney-pans-coronavirus-testing-delays>.

HHS (2020). HHS to provide millions of TYVEK protective suits for U.S. healthcare workers. news release, April 8, HHS, available at: <https://www.hhs.gov/about/news/2020/04/08/hhs-provide-millions-tyvek-protective-suits-us-healthcareworkers.html>

Mint (April 24, 2020). Maruti joins hands with AgVA Healthcare to supply 10,000 ventilators by May-end. <https://www.livemint.com/companies/news/maruti-joins-hands-with-agva-healthcare-to-supply-10-000-ventilators-by-may-end-11587747735201.html>.

1 Mint (March 27, 2020). Covid-19: Mahindra's indigenously developed ventilator to cost  
2 less than ₹7,500. [https://www.livemint.com/companies/news/coronavirus-m-m-ready-  
3 with-ventilator-prototype-to-cost-less-than-rs-7-500-11585228399566.html](https://www.livemint.com/companies/news/coronavirus-m-m-ready-with-ventilator-prototype-to-cost-less-than-rs-7-500-11585228399566.html)  
4

5 The Hindu (March 23, 2020). Reliance sets up India's first dedicated coronavirus hospital.  
6 [https://www.thehindu.com/business/reliance-sets-up-indias-first-dedicated-covid-19-  
7 hospital/article31145158.ece](https://www.thehindu.com/business/reliance-sets-up-indias-first-dedicated-covid-19-hospital/article31145158.ece)  
8  
9

10 The Wire (April 24, 2021). COVID-19: Oxygen Is Crucial – but It's Not Easy To Increase  
11 Supply on Short Notice. [https://science.thewire.in/health/covid-19-oxygen-is-crucial-but-  
12 its-not-easy-to-increase-supply-on-short-notice/](https://science.thewire.in/health/covid-19-oxygen-is-crucial-but-its-not-easy-to-increase-supply-on-short-notice/) Accessed on June 27, 2021.  
13  
14  
15

16 The Wire (January 21, 2021). COVID-19 Vaccine Hesitancy Worries Centre.  
17 <https://science.thewire.in/health/covid-19-vaccine-hesitancy-worries-centre/>. Accessed on  
18 June 27, 2021.  
19  
20

21 The Wire (May 7, 2021). 178+ COVID Patients Died in India Because of Oxygen Shortage  
22 in Recent Weeks. [https://science.thewire.in/health/178-covid-patients-died-in-india-  
23 because-of-oxygen-shortage-in-recent-weeks/](https://science.thewire.in/health/178-covid-patients-died-in-india-because-of-oxygen-shortage-in-recent-weeks/) Accessed on June 27, 2021.  
24  
25  
26  
27  
28  
29  
30  
31  
32  
33  
34  
35  
36  
37  
38  
39  
40  
41  
42  
43  
44  
45  
46  
47  
48  
49  
50  
51  
52  
53  
54  
55  
56  
57  
58  
59  
60  
61  
62  
63  
64  
65