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Assessing Effectiveness of Humanitarian Activities against COVID-19 Disruption: The Role of Blockchain-enabled Digital Humanitarian Network (BT-DHN)

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Abstract: COVID-19 pandemic has affected more than 214 countries across the world, disrupting the supply of essential commodities. As the pandemic spread, humanitarian activities (HAs) deem to manage the various situation but appear ineffective due to lack of collaboration, information sharing, inability to respond towards disruption etc. This study aims to determine and provide insights into the critical factors that may enhance the Effectiveness of HAs during the pandemic. A systematic literature review was undertaken to explore critical factors and validated by experts using the Fuzzy-Delphi method. These were further assessed to identify the cause-and-effect relationship by means of the Fuzzy Decision-Making Trial and Laboratory (DEMATEL) method. The results show that building a blockchain-enabled Digital Humanitarian Network (BT-DHN) is the most significant factor during the pandemic. The use of digital platforms for sharing real-time information enhances the Effectiveness of HAs. This study offers stakeholders, policymakers and decision-makers to consider these factors in strategic planning to deal with pandemic disruption.

Keywords: Humanitarian Activities (HAs), Humanitarian Organisation (HO), Pandemic disruption; COVID-19; BlockChain Enabled Digital humanitarian networks (BT-DHN)

1. Introduction

Natural disasters such as earthquakes, tornados, wildfires, floods etc., inevitably disrupt the supply chains regionally or globally [1]. The disruptions are seen in any form: could be the shortage of materials, a temporary peak in demand of essential items, and stimulates fear of resource scarcity, uncontrollable environment and many such undesirable events. Humanitarian Supply Chains (HSCs) appear hastily to manage such disruptions and uncertainties [2][3]. However, developing an HSC is often more complex when compared to the general commercial supply chain [4]. The disruption caused by the virus outbreaks such as coronavirus (2019-nCoV) in China, the Zika virus, avian influenza A (H7N9), and Ebola virus (Zaire strain) in West Africa created a threat on human health

and safety that questions the readiness/preparedness of any organization in meeting such emergency. The rise of the supply of 'essential items' (items of daily needs) and medical equipment (Personal protection equipment, surgical mask, ventilators) faces unprecedented demand and much higher volume in comparison to the pre-COVID-19 situation [5][6]. The imbalance of demand and supply and the threat to human lives warrants humanitarian activities that offer long-term and short-term aid to the affected population. We define humanitarian activities (HAs) as the humanitarian emergency support offered to rescue any vulnerable individual or a group of individuals in a community by a collaborative effort of humanitarian organizations and their stakeholders. In an emergency, organizations need enhanced operational efficiencies and effective logistics services for vulnerable communities. These organizations, henceforth called Humanitarian organizations (HOs), are required to be agile and adaptive to manage the emergency [4][7][8]. The role of digital technologies, including blockchain, in humanitarian activities, is highly significant during the time of emergency [2][4] [9][10][99]. BT are useful in the designing and development of the digital humanitarian network. Thus, the BT enabled DHNs can bring more clarity and accessibility among actors and flawless movement of disaster aids and information across the supply chains [10][11][12][13][14][100]. Humanitarian aid usually has a linear flow of supplies to the affected areas, especially to regions where the need is higher [14]. During COVID-19, the commercial supply chains deliver the needed supplies. However, humanitarian aids require a vast network and resource prediction until it is needed [15][16][17][18]. This acts as a limiting factor for HOs as multiple stakeholders are present in the supply chain. The development of humanitarian strategies and continuous assessment of humanitarian abilities of the cross-sector partners is important for sourcing essentials and strategic supplies [20]. The supply chain disruptions can be mitigated using a few operational strategies, including maintaining safety stock or exclusive supplies of healthcare products like masks, hand sanitizers, protective gear and ventilators from alternative sources through mobilization of resources [21]. Based on experiences from the past, humanitarian activities should include initiating the action plan and its implementation in cost-effective ways to ensure the flow of goods and services to a vulnerable group of people [22][23][24][25]. Therefore, creating a responsive portfolio of customized humanitarian services has become a major concern and topic of discussion by global disaster planners, humanitarian partners, researchers and practitioners, including the World Health Organization (WHO). Since the 1990s, the WHO has highlighted the need for sustainable partnerships among various stakeholders (including government, researchers, nonprofit organizations, private firms and R&D entities) contributing to a variety of HAs in response to disaster mitigation [24][25]. The COVID-19 endemic is considered the worst crisis since Second World War [26][27]. As defined by the International Federation of Red Cross and Red Crescent Societies, COVID-19 is categorized as a natural hazard[26]. Disaster risk management has a relationship with the type of disaster, vulnerability and exposure as explained in this formula: risk= disaster*vulnerability*exposure [27][28]. For reducing risks, besides disaster prevention, it is required to plan and reduce vulnerability and exposure. Thus, The operational Effectiveness in the pandemic situation cannot be seen as a whole; it needs to be broken down into meaningful and efficient sub-systems to measure its Effectiveness [29][30]. However, research in space is quite limited. Refer to Table 2 for all those research that mostly addressed the single success factors. But validation of those success factors using the Fuzzy-Delphi method and subsequently assessing through cause-and-effect relationship by Fuzzy Decision-Making Trial and Laboratory (DEMATEL) is new in this study. The present research, therefore, aims to evaluate the HAs in the context of a pandemic situation and to identify these critical factors for their efficiencies and Effectiveness. The following research questions are developed to answer this objective.

RQ1. What critical factors contribute to the development of effective HAs in COVID-19?

RO2. What interrelationship and hierarchy exist between these Critical Factors (CFs).

RO3: To what extent do these critical factors have cause-and-effect interrelationships?

The outcomes of the study will facilitate the disaster planners and strategists to guide their humanitarian supply chain to effectively implement HAs during the pandemic. The study contributes a set of HAs in context to the COVID-19 pandemic. Methodologically, this study employed a systematic literature review followed by the assessment of factors using Fuzzy-DEMATEL. The paper is organized as below. Section 2 captures the various critical factors based on a systematic literature review. Section 3 describes the research methodology undertaken in the study. Section 4 gives detailed elaboration on Fuzzy-Delphi and Fuzzy-DEMATEL methods. Section 4 elaborates the application of methods for validation and cause and effect interrelationships computations. Section 5 presents the discussion of the findings of the study. Section 6 highlights the implications followed by the conclusion and limitations in section 7.

2. Literature

A systematic literature review was undertaken to search articles published from 2000 to 2020. Table 1 presents the search criteria used in the literature review.

Table 1. Search Criteria.

Search terms	Initial search	First screening	Second screening	Third screening	Fourth screening
“Humanitarian” AND "Pandemic"	15	11	9	8	5
"Humanitarian operations" AND "Pandemic”	21	12	11	10	6
Humanitarian Logistics" AND "COVID-19"	25	20	18	15	12
Critical Success Factors" AND "Humanitarian”	27	11	10	9	5
Total articles					28

The first search resulted in 88 articles. After removing the duplicates, it came down to 54; narrowing down only to journal articles resulted in 48 articles, exclusion of unrelated articles retained 42 articles, and finally, abstract checking resulted in 28 papers. From the selected papers, factors were identified. This followed an expert survey where each expert thoroughly read the description of these critical factors in the questionnaire and evaluated them according to their significance in the enhancement of organizational Effectiveness. The detailed elaboration of the factors of HAs to enhance operational activities during a pandemic is discussed in section 2.1.

2.1. Humanitarian Activities (HAs) in enhancing operational Effectiveness during the pandemic

Developing a sustainable humanitarian supply chain (HSC) for managing disasters/emergencies can be viewed as an extension of the traditional supply chain [31][18][32]. Thus, sustainable HSCs have evolved as a specialized discipline with a focus on social Sustainability [33][34]. Various parties (including NGOs, local and regional relief organizations, government agencies, HOs, beneficiaries) and other stakeholders from the corporate sector comprise a centralized or a decentralized HSC structure [33][34][35]. that aims to relieve the masses at risk. Otherwise, a single actor individually may not have sufficient resources to respond effectively to major disasters, including COVID-19 [36][37][38][39].HAs to play a critical role in a disaster. Coordination among humanitarian parties/actors can strengthen and enhance the outcomes through resource and information sharing, decision-making, conducting joint-field surveys, or cluster-based services towards social needs [40][41][42][43]. Figure 1 illustrates the conceptual framework on critical factors of HAs influencing operational Effectiveness of HOs. These HAs improved

resilience through vertical and horizontal coordination among the actors [44][45][46][48]. In the light of Blockchain technology, The Effectiveness of HSC results in a smooth flow of suppliers, information and resources to the beneficiaries and can be measured in terms of response time by using the common elements of supply chain philosophy *"delivery of right goods, at the right time, to the right place, and to the right set of people"*. Thus, a Blockchain driven HSC can be simply defined as a traceable system available to all stakeholders of HSC for effective roles and responsibility of the disaster migration and effective humanitarian activities [2][4][10].

The HAs also result in the development of local and regional infrastructure. Hence, a successful HSC management through HAs thrives to achieve supply of "essential items" and help in mass evacuation of the community affected by disaster [47], through a process of cost-effective flow and storage of goods and materials from the point of origin to the point of consumption for the purpose of meeting the end beneficiary's requirements [49][50]. A typical design of an HSC should be able to manage the available resources efficiently and enable the community to make the right decision by involving local authority through decentralized decision making. Usage of technology can help HOs to plan capacity, to engage resources and to improve demand prediction. The performance of HSC can be measured by its delivery performance (time, coverage, supply chain responsiveness and cost involved. The COVID-19 is a global outbreak that leads to a sharp and radical shortage of essential supplies (i.e., PPEs, ventilators, protection masks, sanitizers, Hydroxychloroquine). The HSC partners mean to mitigate the global COVID-19 pandemic situation and to ensure critical supplies to aid recipients. An HSC ensures 'line of sight' along with COVID-19 mitigation, prioritized within the wider set of HAs.

With the increasing pressure due to the loss of human lives, it is necessary to conduct a study that aims to determine the critical factors of HAs. Multiple stakeholders (parties including Government and Private sector) strategically coordinate with each other to perform varieties of HAs to aid recipients. Thus, a strategic tie-up has a positive influence on the performance of HSC and increases its sharing capabilities [51][52][53]. Past literature stressed the feedback mechanism among the stakeholders in an HSCs system for developing a reference model[1][47][50]. The coordination among humanitarian actors can be increased by cost-effective usage of resources and involvement of top-level managers in distribution roles [54][55][56]. Regular interactions between humanitarian actors are essential for the Effectiveness of HAs. Effective communication measures to reduce pressure among supply chain actors and optimize the supply of essentials. Usage of ICT ensures the transparency and flawless exchange of information across the HSCs. Also, it increases the flexibility, agility and alignment in emergency decisions. The commitment of humanitarian actors supports the aims of HOs in developing mutual consent towards operational decisions [54]. Effective training of the actors about a pandemic situation helps build capacity to respond more effectively during various disaster situations [55][56]. Various critical success factors are elaborated in Table 2.

Table 2. Critical Success Factors to enhance operational Effectiveness of Humanitarian Activities.

Critical Factors	Operational Effectiveness during the pandemic	References
Multi-modal transportation **(C-HA1)**	Usage of Multi-modal transportation can connect all supply nodes, affected areas and logistics operational areas.	[57][58][59][60]
Leadership during Pandemic Crisis **(C-HA2)**	Communicating with teams, stakeholders, and communities during COVID-19 enhance transparency, demonstrate vulnerability and build resilience among Humanitarian organizations.	[61][62]
Empowering the Stakeholders **(C-HA3)**	Empowerment of the stakeholders helps the Humanitarian organizations to identify clear vision, competency and coordination across all levels.	[63][64][99]

Risk Communication and Community engagement **(C-HA4)**	Risk Communication across stakeholders bring transparency and pro-activeness towards the pandemic situation.	[65][66][100]
Information resource orchestration **(C-HA5)**	Adoption of information resource activities and information behaviour activities can meet the need of Humanitarian Operations.	[67][68][99][100]
Agile and Adaptive Governance **(C-HA6)**	Participation collaboration and governance become more agile and adaptive during the pandemic.	[69][70] [71]
Information system**(C-HA7)**	Information System planning should address challenges, value generation processes, and resource base in an effort to improve organizational performance	[72][73][74]
Capacity building of stakeholders **(C-HA8)**	A competency-based teaching approach can improve the intercultural pandemic training among the stakeholders who can further improve interdisciplinary integration, enhancing the overall operational Effectiveness.	[75][76]
BlockChain enabled Digital Humanitarian Network (BT-DHN) **(C-HA9)**	BlockChain enabled Digital Humanitarian Network (BT-DHN)s ensures participative management and real-time information flow that uses big data for the humanitarian response for effective relief operations.	[77][78][79]
Maintaining Essential Heath Services **(C-HA10)**	Adjust governance and coordination mechanisms to support timely action for essential health services, and adapt to changing contexts and needs.	[80][81][82]
Inter-organizational coordination and collaboration **(C-HA11)**	Collaborative planning for responding the pandemic(through cooperation, interaction and collaboration among relief agencies).	[83][84][85] [86]
Preparedness and pandemic response practices **(C-HA12)**	Preparedness planning and COVID-19 response practices emerged as the key humanitarian activity among humanitarian actors.	[9][87][88]
Surveillance for Vulnerable Groups **(C-HA13)**	It aims to limit the spread of the pandemic in vulnerable groups (children, women, and old-aged population) by rapid detection, isolation, testing and management.	[89][90]
Prevention and Control **(C-HA14)**	Infection Prevention and Control (IPC) is the key humanitarian activity. IPC occupies a unique position in the field of patient safety and quality universal health coverage.	[77][78]
Human security **(C-HA15)**	It is protecting human life, especially the vulnerable groups, by involving local government and partners to increase operational Effectiveness.	[71][84]
Societal response **(C-HA16)**	It is the collective efforts of humanitarian organizations, the corporate world, government and the community to fight collectively against the pandemic. Based on the principle of 'Respond, Recover and Rebuild', the societal response to the COVID-19 pandemic is a continuous improvement process.	[49][62]

3. Research Methodology

In the past literature, quantitative methods used were either probabilistic techniques, statistics or both. Although they have several limitations that deals with vagueness and issues of scalability. To delimit these issues, the present study has used an applicable and advanced methodology to assess the Effectiveness of the Humanitarian Activities and to simplify its role during COVID-19 disaster management [82][90][92][93]. A three-phase study was conducted, as illustrated in Figure 2. During the first phase, the systematic literature review was conducted to identify HAs, followed by the experts' brainstorming session [41][75]. The detail of experts is presented in section 4. Based on the responses collected from the experts, validation of the HAs was done using Fuzzy-Delphi. In the second phase, the HAs were assessed using the Fuzzy-DEMATEL method to establish the cause-and-effect relationship among them.

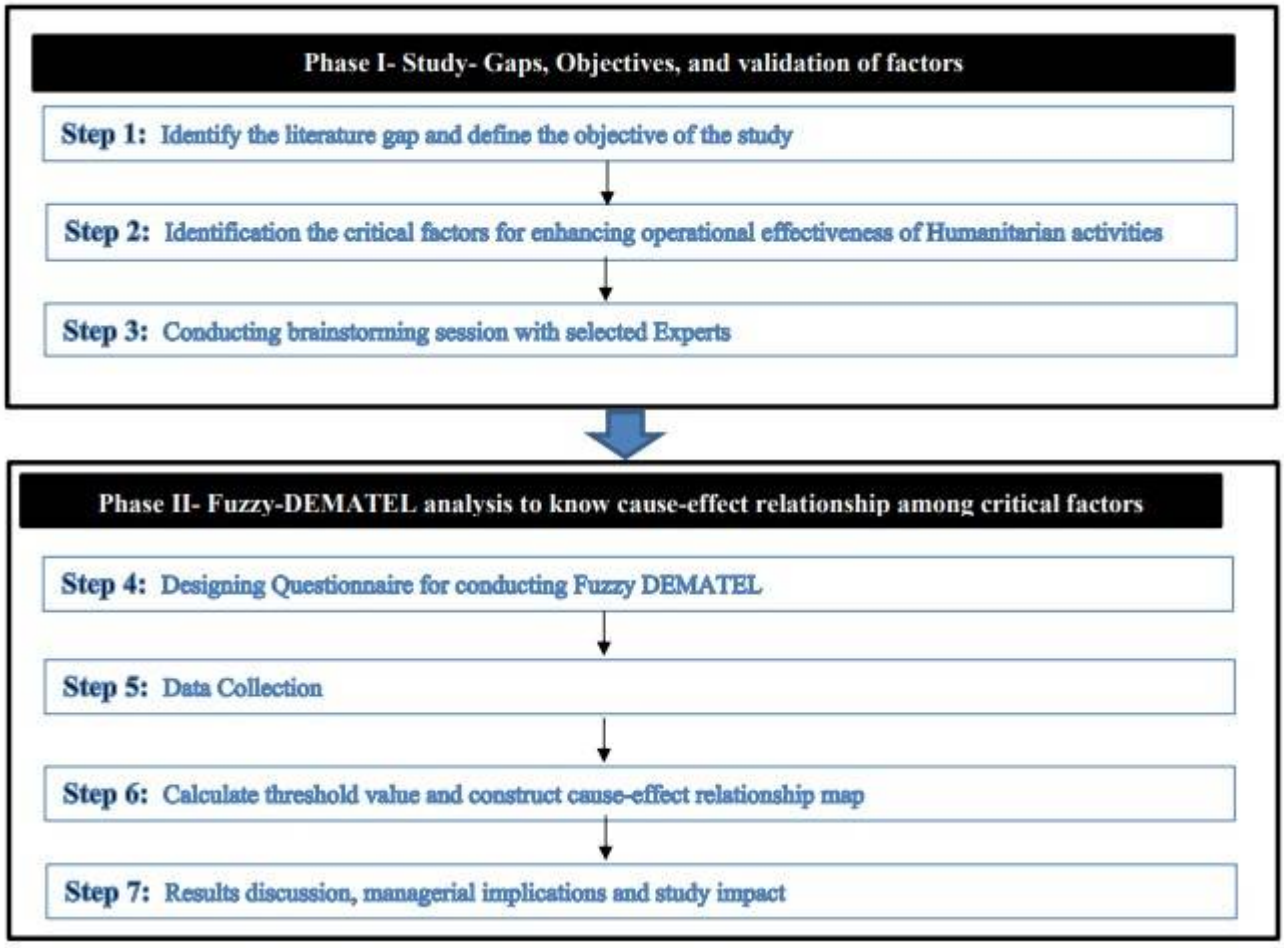

Figure 2. Proposed research framework.

The fuzzy-Delphi and fuzzy-DEMATEL methods are elaborated in the subsequent sub-sections.

3.1. Fuzzy Set Theory

The decision making in context to HAs is complex due to the involvement of multiple actors as well as the subjectivity in judgment due to ambiguity in the data and information. Thus, fuzzy theory helps the decision-makers to clarify human responses in the crisp form under imprecise and uncertain situations [85][86]. In a fuzzy set, binary numbers 0 and 1 represent each number in an interval [0, 1]. The fuzzy-based analysis can be defined as – if 'X' explains a set of elements and the general component of 'X' is explained

through 'x' with values ($x_1, x_2, x_3 \ldots\ldots\ldots x_n$). The fuzzy set C for X can be stated as $\{(x, \mu_C(x)) \mid x \in X\}$. The membership of this fuzzy set C can be defined through $\mu_C(x)$.

Let us assume, 'A' and 'B' are two TFNs and represented as - A = (p1, q1, r1) and B = (p2, q2, r2). The membership function for the TFN (p, q, r) is calculated using the expression provided in Eq. (1).

$$\mu_C(x) = \begin{Bmatrix} 0, x \le p \\ \frac{x-p}{q-p}, x \in [p, q] \\ \frac{x-r}{q-r}, x \in [q, r] \\ 0, \text{otherwise} \end{Bmatrix} (1) \quad (1)$$

Then, the algebraic operations for A and B as per the extension principle,

1. A⊕B: $(p_1, q_1, r_1) \oplus (p_2, q_2, r_2) = (p_1 + p_2, q_1 + q_2, r_1 + r_2)$
2. A ⊖ B: $(p_1, q_1, r_1) \ominus (p_2, q_2, r_2) = (p_1 - p_2, q_1 - q_2, r_1 - r_2)$
3. A⊗B: $(p_1, q_1, r_1) \otimes (p_2, q_2, r_2) \cong (p_1 p_2, q_1 q_2, r_1 r_2)$
4. ʎ (A⊗B): $ʎ \otimes (p_1, q_1, r_1) = (ʎp_1, ʎq_1, ʎr_1)$
5. A∅ B: $(p_1, q_1, r_1) \oslash (p_2, q_2, r_2) \cong (p_1/r_2, q_1/q_2, r_1/p_2$

3.2. Fuzzy Delphi Method

The Fuzzy based Delphi [78] has the capability to capture vagueness in data. Several studies have used this method for measuring firm performance [81][82]; performance of green supply chain management [89][91]; technology selection [87]; and logistics [9][94]. This study has applied Fuzzy Delphi to obtain the joint decision making that aims to assess the critical factors for HAs to develop humanitarian supply chains. The process is elaborated in the following steps.

Step 1: It includes the extraction of HAs from the existing literature. The extraction is exhibited in Figure 1.

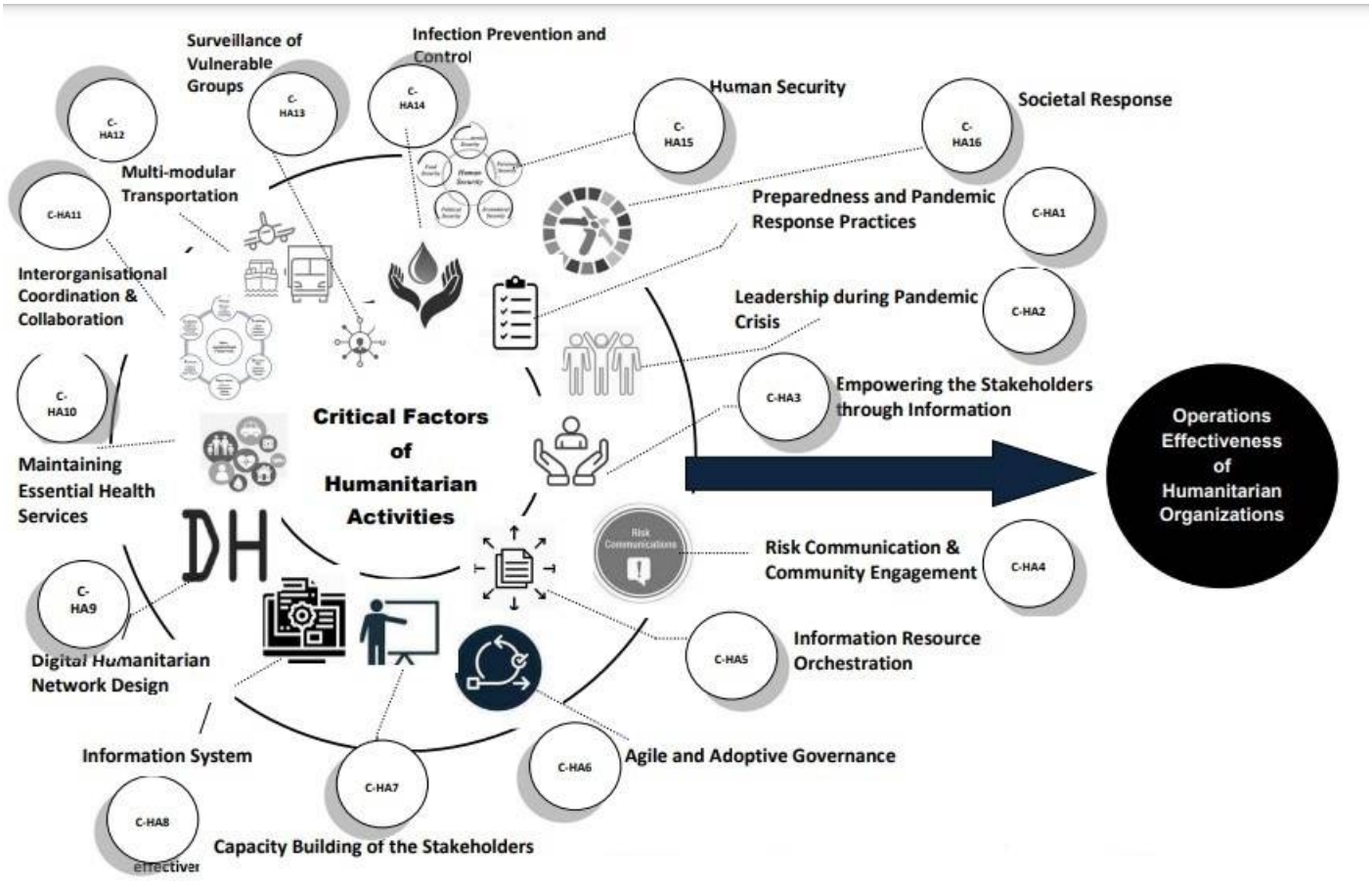

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Figure 1. Conceptual framework of critical factors of humanitarian activities influencing Humanitarian operations

Step 2: The identified HAs were shared with the experts. With the help of the linguistic scale (Table 3), the HAs are evaluated. Assuming fuzzy number $\tilde{z}_{ij}$ to be the jth evaluation of barriers of the ith expert of n experts.

$$\tilde{z}_{ij} = (a_{ij,}\ b_{ij,}, c_{ij})$$

$$\text{for } i = 1, 2, 3, \ldots., n \text{ and } j = 1, 2, 3, \ldots, m \quad (2)$$

Then, the fuzzy weights of barriers $\tilde{a}_j$ are given as follows: $\tilde{a}_j = (a_j, b_j, c_j)$

Where,

$$a_j = \min(a_{ij}), \quad (3)$$

$$b_j = \left(\prod_{i=1}^{n}(b_{ij})\right)^{1/n} \quad (4)$$

$$c_j = \max(c_{ij}), where, i = 1, 2, \ldots, n, j = 1, 2, \ldots m$$

Step 3: This final step uses mean method Sj that is obtained by Eq. (4).

$$S_j = (a_j + b_j + c_j)/3, \quad \text{j} = 1, 2, \ldots..\text{m} \quad (4)$$

The evaluation of critical factors is based on the following condition:

a) Acceptance of factor: When the value of S_j is greater or equal to the threshold value (α)

b) Rejection of the factor: When the Value of S_j is less than a threshold value (α)

3.3. Fuzzy DEMATEL

In a multi-variable decision making fuzzy and complex supply chain management problem fuzzy- DEMATEL can be used as an effective tool [75][95]. Broadly, the mathematical process can be explained as follows:

Step I: Goal setting and criteria identification

Step II: Factors identification to evaluate effect between factors using pairwise comparison.

Step III: Define the fuzzy linguistic scale. Table 3 explains the linguistic terms used in the study.

Table 3. Scale labelling.

Terms for Scale	Number	linguistic terms
Very influence (VI)	4	(0.75,1.0,1.0)
High influence(HI)	3	(0.5,0.75,1.0)
Low influence (LI)	2	(0.25, 0.5, .75)
Very low influence (VLI)	1	(0, 0.25, 0.5)
No influence (NI)	0	(0, 0, 0.25)

Step IV: Development of fuzzy direct-relation matrix Z^k. $Z^k = [Z^k{}_{ij}]$ where Z is a $n \times n$ non-negative matrix; Z_{ij} represents the direct impact of factor i on factor j; and, when i = j, the diagonal elements $Z_{ij} = 0$.

Step V: Establishment of the cause-and-effect model: Compute the total-relation matrix T using the formula in Eq. 13, where n × n identity matrix is represented with I. Upper, and lower values are calculated separately

$$T = D(I - D)^{-1} \quad (5$$

Step VI: The cause-and-effect group factors provides the visualization of the complex interrelationships among factors and are highly significant for decision-makers.

4. Research Framework

The methods are applied sequentially as shown in Figure 2. The framework is elaborated as follows:

4.1. Phase 1- Identification and validation of critical factors for HAs through brainstorming

From the literature review, sixteen critical success factors related to HAs were identified. A brainstorming session was conducted online to identify the perception of health officials and humanitarian organizations (NGOs, private healthcare staff). The data was collected through a questionnaire with an additional sheet to include any extra critical factors. A panel of 11 experts with different expertise over 10 years were engaged in the brainstorming session. The details of the experts are given in Table 4.

Table 4. Details of experts.

Expert Code	Designation	Age (years)	Industry	Experience (Years)	Expertise
E1	Healthcare professional	> 45	Health care	>15	Patient care
E2	Healthcare professional	> 45	Health care	>15	Patient care
E3	Disaster Management expert	> 35	Healthcare	>12	Healthcare
E4	Disaster Management expert	> 40	Healthcare	>15	Healthcare
E5	Disaster Management expert	> 40	Healthcare	>15	Healthcare
E6	NGO	> 40	Social well being	>15	Societal issue
E7	Manager	>35	Healthcare	>15	Healthcare
E8	Healthcare Staff	> 35	Healthcare	>10	Patient care
E9	Professor	>45	Higher education	>20	Healthcare
E10	Professor	>45	Higher education	>20	Healthcare
E11	Healthcare Staff	> 35	Healthcare	>10	Patient care

The responses were collected from the experts based on the linguistic label shown in Table 3. A threshold value was set more than 0.60 for exclusion and inclusion of the factors based on the previous literature. The experts were also asked to include any factor which they feel can influence the HAs during the pandemic. But the experts did not suggest any change and were satisfied with the factors they were provided. Through the Fuzzy-Delphi method, the factors were assessed and validated. Section 3.1 discussed the steps for computing Sj, and its final values are exhibited in Table 5.

Table 5. Scores for variables were undertaken using Fuzzy-Delphi.

S. N	Critical factors for HAs	L	m	u	S
1	Multi-modal transportation **(C-HA1)**	0.25	0.89	1.00	0.712
2	Leadership during Pandemic Crisis **(C-HA2)**	0.25	0.80	1.00	0.682
3	Empowering the Stakeholders through Information **(C-HA3)**	0.25	0.84	1.00	0.697
4	Risk Communication and Community engagement **(C-HA4)**	0.25	0.82	1.00	0.689
5	Information resource orchestration	0.30	0.82	1.00	0.706

	(C-HA5)				
6	Agile and Adaptive Governance **(C-HA6)**	0.25	0.75	1.00	0.667
7	Information system**(C-HA7)**	0.25	0.84	1.00	0.697
8	Capacity building of stakeholders **(C-HA8)**	0.25	0.86	1.00	0.705
9	Prevention and Control**(C-HA9)**	0.25	0.82	1.00	0.689
10	Maintaining Essential Heath Services **(C-HA10)**	0.25	0.80	1.00	0.682
11	Inter-organizational coordination and collaboration **(C-HA11)**	0.25	0.75	1.00	0.667
12	Preparedness and pandemic response practices **(C-HA12)**	0.25	0.80	1.00	0.682
13	Surveillance for Vulnerable Groups **(C-HA13)**	0.25	0.82	1.00	0.689
14	BlockChain enabled Digital Humanitarian Network (BT-DHN) Design **(C-HA14)**	0.25	0.77	1.00	0.673
15	Human security **(C-HA15)**	0.25	0.82	1.00	0.689
16	Societal response **(C-HA16)**	0.00	0.70	1.00	0.568

The values of Sj in Table 5 suggest that all the variables identified from the literature are valid and must be undertaken for the study as all the values are higher than 0.60.

4.2. Fuzzy DEMATEL for Cause-and-Effect Analysis

The Fuzzy DEMATEL was applied to establish a cause-and-effect relationship among the sixteen critical factors. The factors were assessed on a linguistic scale mentioned in Table 3. The normalized fuzzy numbers and total relation matrix derived from the step-by-step process are shown in Table 6.

Table 6. Total Normalized Direct-Relation Matrix (X) for l, m, u.

(l)																
Factors	**C-HA1**	**C-HA2**	**C-HA3**	**C-HA4**	**C-HA5**	**C-HA6**	**C-HA7**	**C-HA8**	**C-HA9**	**C-HA10**	**C-HA11**	**C-HA12**	**C-HA13**	**C-HA14**	**C-HA15**	**C-HA16**
C-HA1	0	0.0162	0.0129	0.0323	0.0356	0.0209	0.0210	0.0339	0.0387	0.0242	0.0355	0.0355	0.0338	0.0388	0.0355	0.0258
C-HA2	0.0209	0	0.0178	0.0501	0.0162	0.0161	0.0193	0.0388	0.0242	0.0194	0.0258	0.0145	0.0210	0.0194	0.0226	0.0340
C-HA3	0.0210	0.0194	0	0.0355	0.0323	0.0097	0.0000	0.0388	0.0291	0.0243	0.0323	0.0242	0.0259	0.0275	0.0064	0.0161
C-HA4	0.0308	0.0194	0.0000	0	0.0533	0.0178	0.0210	0.0323	0.0226	0.0194	0.0242	0.0178	0.0162	0.0178	0.0226	0.0356
C-HA5	0.0370	0.0032	0.0323	0.0000	0	0.0355	0.0178	0.0323	0.0146	0.0323	0.0388	0.0291	0.0275	0.0290	0.0194	0.0356
C-HA6	0.0306	0.0243	0.0032	0.0242	0.0355	0	0.0178	0.0355	0.0178	0.0355	0.0307	0.0323	0.0355	0.0211	0.0339	0.0242
C-HA7	0.0322	0.0194	0.0242	0.0210	0.0178	0.0161	0	0.0291	0.0178	0.0355	0.0501	0.0323	0.0469	0.0356	0.0371	0.0436
C-HA8	0.0258	0.0226	0.0274	0.0162	0.0178	0.0178	0.0355	0	0.0064	0.0064	0.0112	0.0291	0.0469	0.0339	0.0371	0.0372
C-HA9	0.0274	0.0177	0.0307	0.0177	0.0194	0.0226	0.0355	0.0355	0	0.0194	0.0340	0.0323	0.0323	0.0501	0.0371	0.0372
C-HA10	0.0322	0.0193	0.0259	0.0162	0.0113	0.0209	0.0161	0.0178	0.0178	0	0.0533	0.0194	0.0178	0.0226	0.0355	0.0340
C-HA11	0.0193	0.0323	0.0355	0.0097	0.0259	0.0290	0.0355	0.0290	0.0533	0.0178	0	0.0517	0.0501	0.0210	0.0517	0.0355
C-HA12	0.0291	0.0307	0.0355	0.0259	0.0323	0.0419	0.0484	0.0484	0.0533	0.0178	0.0533	0	0.0533	0.0226	0.0178	0.0404

C-HA13	0.0323	0.0371	0.0404	0.0226	0.0355	0.0209	0.0322	0.0323	0.0355	0.0178	0.0355	0.0355	0	0.0194	0.0194	0.0356
C-HA14	0.0436	0.0485	0.0420	0.0161	0.0388	0.0210	0.0355	0.0469	0.0355	0.0178	0.0355	0.0178	0.0355	0	0.0517	0.0355
C-HA15	0.0420	0.0452	0.0452	0.0161	0.0259	0.0242	0.0355	0.0533	0.0355	0.0178	0.0242	0.0178	0.0355	0.0178	0	0.0501
C-HA16	0.0420	0.0307	0.0501	0.0420	0.0194	0.0128	0.0404	0.0371	0.0517	0.0371	0.0436	0.0210	0.0355	0.0211	0.0178	0
								(m)								
C-HA1	0	0.0340	0.0307	0.0501	0.0534	0.0387	0.0387	0.0517	0.0565	0.0420	0.0532	0.0533	0.0516	0.0565	0.0533	0.0436
C-HA2	0.0387	0	0.0355	0.0679	0.0242	0.0339	0.0371	0.0565	0.0420	0.0372	0.0436	0.0323	0.0388	0.0372	0.0404	0.0517
C-HA3	0.0387	0.0372	0	0.0533	0.0501	0.0274	0.0178	0.0566	0.0469	0.0420	0.0501	0.0419	0.0436	0.0453	0.0242	0.0339
C-HA4	0.0486	0.0372	0.0178	0	0.0711	0.0355	0.0388	0.0501	0.0404	0.0372	0.0420	0.0356	0.0340	0.0355	0.0404	0.0533
C-HA5	0.0548	0.0210	0.0501	0.0178	0	0.0533	0.0355	0.0501	0.0324	0.0501	0.0565	0.0468	0.0452	0.0468	0.0371	0.0533
C-HA6	0.0484	0.0420	0.0210	0.0420	0.0533	0	0.0355	0.0533	0.0355	0.0533	0.0485	0.0501	0.0533	0.0389	0.0517	0.0420
C-HA7	0.0500	0.0372	0.0420	0.0387	0.0355	0.0339	0	0.0469	0.0355	0.0533	0.0679	0.0501	0.0647	0.0533	0.0549	0.0614
C-HA8	0.0435	0.0404	0.0452	0.0340	0.0355	0.0355	0.0533	0	0.0242	0.0242	0.0290	0.0469	0.0647	0.0517	0.0549	0.0550
C-HA9	0.0452	0.0355	0.0484	0.0354	0.0372	0.0403	0.0533	0.0533	0	0.0372	0.0517	0.0501	0.0501	0.0679	0.0549	0.0549
C-HA10	0.0500	0.0371	0.0436	0.0340	0.0291	0.0386	0.0339	0.0355	0.0355	0	0.0711	0.0372	0.0355	0.0404	0.0533	0.0517
C-HA11	0.0371	0.0500	0.0533	0.0275	0.0437	0.0468	0.0533	0.0468	0.0711	0.0355	0	0.0695	0.0679	0.0388	0.0695	0.0533
C-HA12	0.0468	0.0484	0.0533	0.0436	0.0501	0.0597	0.0661	0.0661	0.0711	0.0355	0.0711	0	0.0711	0.0404	0.0355	0.0582
C-HA13	0.0501	0.0549	0.0581	0.0404	0.0533	0.0387	0.0500	0.0501	0.0533	0.0355	0.0533	0.0533	0	0.0372	0.0371	0.0533
C-HA14	0.0614	0.0663	0.0598	0.0339	0.0566	0.0388	0.0533	0.0647	0.0533	0.0355	0.0533	0.0355	0.0533	0	0.0695	0.0533
C-HA15	0.0597	0.0630	0.0630	0.0339	0.0437	0.0420	0.0533	0.0711	0.0533	0.0355	0.0420	0.0355	0.0533	0.0355	0	0.0678
C-HA16	0.0598	0.0484	0.0679	0.0598	0.0371	0.0306	0.0581	0.0549	0.0695	0.0549	0.0614	0.0387	0.0533	0.0389	0.0355	0
								(u)								
C-HA1	0	0.0485	0.0484	0.0679	0.0630	0.0549	0.0565	0.0678	0.0678	0.0598	0.0646	0.0646	0.0613	0.0630	0.0646	0.0598
C-HA2	0.0533	0	0.0533	0.0711	0.0388	0.0517	0.0533	0.0711	0.0565	0.0549	0.0582	0.0484	0.0566	0.0549	0.0582	0.0614
C-HA3	0.0533	0.0550	0	0.0711	0.0678	0.0420	0.0355	0.0679	0.0598	0.0566	0.0614	0.0549	0.0582	0.0550	0.0420	0.0517
C-HA4	0.0598	0.0550	0.0355	0	0.0711	0.0533	0.0565	0.0679	0.0566	0.0550	0.0565	0.0518	0.0518	0.0533	0.0581	0.0662
C-HA5	0.0629	0.0388	0.0679	0.0355	0	0.0711	0.0533	0.0647	0.0469	0.0679	0.0711	0.0598	0.0598	0.0581	0.0549	0.0662
C-HA6	0.0565	0.0582	0.0388	0.0565	0.0711	0	0.0533	0.0711	0.0533	0.0711	0.0663	0.0662	0.0695	0.0550	0.0695	0.0598

C-HA7	0.0629	0.0533	0.0565	0.0549	0.0533	0.0517	0	0.0647	0.0533	0.0711	0.0695	0.0678	0.0679	0.0695	0.0711	0.0711
C-HA8	0.0597	0.0566	0.0598	0.0485	0.0533	0.0533	0.0711	0	0.0420	0.0420	0.0468	0.0647	0.0679	0.0695	0.0711	0.0663
C-HA9	0.0613	0.0517	0.0598	0.0516	0.0550	0.0549	0.0711	0.0711	0	0.0549	0.0695	0.0679	0.0679	0.0711	0.0711	0.0630
C-HA10	0.0630	0.0533	0.0582	0.0485	0.0452	0.0516	0.0517	0.0533	0.0533	0	0.0711	0.0549	0.0533	0.0582	0.0711	0.0663
C-HA11	0.0501	0.0630	0.0678	0.0453	0.0582	0.0613	0.0711	0.0646	0.0711	0.0533	0	0.0711	0.0711	0.0565	0.0711	0.0646
C-HA12	0.0614	0.0630	0.0678	0.0614	0.0678	0.0645	0.0678	0.0678	0.0711	0.0533	0.0711	0	0.0711	0.0582	0.0533	0.0647
C-HA13	0.0662	0.0694	0.0678	0.0582	0.0678	0.0565	0.0678	0.0679	0.0711	0.0533	0.0711	0.0711	0	0.0549	0.0549	0.0647
C-HA14	0.0711	0.0711	0.0711	0.0517	0.0711	0.0565	0.0711	0.0679	0.0711	0.0533	0.0711	0.0533	0.0711	0	0.0711	0.0678
C-HA15	0.0694	0.0694	0.0711	0.0517	0.0582	0.0581	0.0711	0.0711	0.0711	0.0533	0.0565	0.0533	0.0711	0.0533	0	0.0695
C-HA16	0.0711	0.0662	0.0711	0.0711	0.0549	0.0452	0.0711	0.0711	0.0711	0.0711	0.0678	0.0549	0.0711	0.0550	0.0533	0

Further, total relation matrix is obtained by using the formula described in eq. (13) and shown in Table 7

Table 7. Total relation matrix.

								(l)								
Factors	**C-HA1**	**C-HA2**	**C-HA3**	**C-HA4**	**C-HA5**	**C-HA6**	**C-HA7**	**C-HA8**	**C-HA9**	**C-HA10**	**C-HA11**	**C-HA12**	**C-HA13**	**C-HA14**	**C-HA15**	**C-HA16**
C-HA1	0.0240	0.0363	0.0356	0.0481	0.0558	0.0378	0.0428	0.0605	0.0612	0.0407	0.0608	0.0557	0.0595	0.0580	0.0576	0.0521
C-HA2	0.0396	0.0160	0.0349	0.0628	0.0334	0.0291	0.0364	0.0594	0.0423	0.0328	0.0459	0.0313	0.0416	0.0354	0.0405	0.0544
C-HA3	0.0385	0.0340	0.0169	0.0475	0.0480	0.0229	0.0171	0.0583	0.0461	0.0364	0.0512	0.0400	0.0453	0.0426	0.0240	0.0361
C-HA4	0.0491	0.0342	0.0184	0.0133	0.0678	0.0313	0.0379	0.0529	0.0404	0.0332	0.0448	0.0345	0.0377	0.0340	0.0403	0.0557
C-HA5	0.0566	0.0213	0.0514	0.0157	0.0183	0.0493	0.0363	0.0552	0.0357	0.0468	0.0611	0.0475	0.0506	0.0461	0.0393	0.0570
C-HA6	0.0514	0.0419	0.0240	0.0391	0.0535	0.0158	0.0375	0.0592	0.0388	0.0500	0.0540	0.0508	0.0585	0.0389	0.0538	0.0481
C-HA7	0.0561	0.0408	0.0479	0.0389	0.0395	0.0335	0.0231	0.0569	0.0433	0.0524	0.0762	0.0538	0.0731	0.0553	0.0603	0.0698
C-HA8	0.0457	0.0399	0.0464	0.0316	0.0357	0.0315	0.0530	0.0239	0.0272	0.0216	0.0340	0.0460	0.0679	0.0498	0.0546	0.0586
C-HA9	0.0512	0.0388	0.0534	0.0354	0.0407	0.0391	0.0570	0.0629	0.0246	0.0367	0.0601	0.0531	0.0591	0.0692	0.0597	0.0631
C-HA10	0.0506	0.0360	0.0439	0.0306	0.0286	0.0342	0.0338	0.0402	0.0381	0.0142	0.0730	0.0370	0.0397	0.0386	0.0537	0.0545
C-HA11	0.0457	0.0543	0.0606	0.0300	0.0486	0.0474	0.0594	0.0599	0.0784	0.0370	0.0302	0.0738	0.0786	0.0439	0.0747	0.0646
C-HA12	0.0569	0.0540	0.0617	0.0469	0.0571	0.0610	0.0732	0.0798	0.0801	0.0391	0.0837	0.0273	0.0844	0.0479	0.0459	0.0714
C-HA13	0.0549	0.0556	0.0615	0.0405	0.0556	0.0376	0.0529	0.0592	0.0584	0.0353	0.0614	0.0562	0.0271	0.0401	0.0411	0.0610

C-HA14	0.0695	0.0699	0.0668	0.0369	0.0615	0.0397	0.0591	0.0773	0.0615	0.0376	0.0645	0.0423	0.0652	0.0241	0.0760	0.0652
C-HA15	0.0658	0.0648	0.0677	0.0363	0.0475	0.0410	0.0573	0.0808	0.0595	0.0364	0.0519	0.0405	0.0630	0.0402	0.0240	0.0763
C-HA16	0.0663	0.0514	0.0724	0.0605	0.0425	0.0310	0.0623	0.0659	0.0758	0.0551	0.0716	0.0447	0.0635	0.0442	0.0431	0.0292
(m)																
C-HA1	0.1108	0.1327	0.1362	0.1400	0.1529	0.1281	0.1418	0.1709	0.1636	0.1322	0.1696	0.1540	0.1678	0.1548	0.1590	0.1608
C-HA2	0.1334	0.0866	0.1258	0.1455	0.1128	0.1109	0.1262	0.1591	0.1356	0.1158	0.1447	0.1209	0.1400	0.1236	0.1327	0.1525
C-HA3	0.1319	0.1209	0.0906	0.1302	0.1355	0.1047	0.1070	0.1577	0.1388	0.1189	0.1495	0.1290	0.1432	0.1302	0.1166	0.1345
C-HA4	0.1433	0.1221	0.1106	0.0807	0.1558	0.1137	0.1282	0.1536	0.1344	0.1168	0.1444	0.1247	0.1365	0.1228	0.1332	0.1546
C-HA5	0.1541	0.1130	0.1460	0.1037	0.0940	0.1344	0.1302	0.1597	0.1334	0.1332	0.1641	0.1408	0.1533	0.1380	0.1358	0.1597
C-HA6	0.1507	0.1343	0.1210	0.1277	0.1467	0.0859	0.1328	0.1652	0.1380	0.1377	0.1588	0.1453	0.1626	0.1325	0.1513	0.1527
C-HA7	0.1612	0.1389	0.1500	0.1328	0.1389	0.1257	0.1071	0.1695	0.1483	0.1453	0.1866	0.1541	0.1830	0.1540	0.1632	0.1800
C-HA8	0.1425	0.1299	0.1400	0.1179	0.1270	0.1161	0.1451	0.1108	0.1240	0.1077	0.1366	0.1381	0.1687	0.1405	0.1493	0.1599
C-HA9	0.1556	0.1361	0.1544	0.1285	0.1392	0.1303	0.1564	0.1743	0.1118	0.1293	0.1700	0.1524	0.1684	0.1665	0.1619	0.1725
C-HA10	0.1460	0.1250	0.1365	0.1159	0.1190	0.1177	0.1254	0.1427	0.1333	0.0822	0.1730	0.1283	0.1402	0.1285	0.1473	0.1548
C-HA11	0.1551	0.1555	0.1659	0.1276	0.1512	0.1425	0.1633	0.1764	0.1860	0.1338	0.1287	0.1770	0.1923	0.1465	0.1811	0.1789
C-HA12	0.1707	0.1597	0.1716	0.1482	0.1639	0.1598	0.1813	0.2008	0.1924	0.1400	0.2029	0.1191	0.2030	0.1549	0.1580	0.1906
C-HA13	0.1589	0.1520	0.1619	0.1332	0.1532	0.1285	0.1522	0.1704	0.1617	0.1276	0.1710	0.1552	0.1197	0.1382	0.1443	0.1702
C-HA14	0.1797	0.1722	0.1736	0.1358	0.1652	0.1366	0.1647	0.1952	0.1714	0.1359	0.1811	0.1482	0.1812	0.1116	0.1841	0.1814
C-HA15	0.1725	0.1638	0.1709	0.1319	0.1481	0.1345	0.1594	0.1945	0.1657	0.1315	0.1650	0.1430	0.1752	0.1411	0.1128	0.1882
C-HA16	0.1745	0.1523	0.1769	0.1567	0.1450	0.1262	0.1657	0.1818	0.1830	0.1509	0.1857	0.1485	0.1773	0.1465	0.1501	0.1269
(u)																
C-HA1	0.6146	0.6302	0.6464	0.6282	0.6568	0.6060	0.6709	0.7324	0.6748	0.6366	0.7055	0.6654	0.7030	0.6513	0.6834	0.6966
C-HA2	0.6183	0.5397	0.6046	0.5888	0.5895	0.5604	0.6209	0.6845	0.6181	0.5880	0.6503	0.6048	0.6495	0.5990	0.6303	0.6493
C-HA3	0.6107	0.5842	0.5470	0.5814	0.6084	0.5456	0.5972	0.6734	0.6134	0.5824	0.6457	0.6032	0.6429	0.5918	0.6080	0.6327
C-HA4	0.6297	0.5964	0.5944	0.5265	0.6233	0.5674	0.6293	0.6874	0.6233	0.5937	0.6549	0.6132	0.6511	0.6028	0.6358	0.6593
C-HA5	0.6520	0.6011	0.6429	0.5798	0.5766	0.6008	0.6458	0.7059	0.6348	0.6240	0.6889	0.6402	0.6792	0.6260	0.6528	0.6796
C-HA6	0.6699	0.6406	0.6397	0.6195	0.6653	0.5558	0.6698	0.7371	0.6635	0.6485	0.7089	0.6687	0.7121	0.6457	0.6896	0.6986
C-HA7	0.6911	0.6513	0.6708	0.6329	0.6646	0.6184	0.6346	0.7482	0.6794	0.6630	0.7280	0.6850	0.7270	0.6734	0.7065	0.7245

C-HA8	0.6468	0.6147	0.6330	0.5893	0.6245	0.5823	0.6591	0.6425	0.6279	0.5980	0.6641	0.6412	0.6834	0.6334	0.6639	0.6769
C-HA9	0.6922	0.6523	0.6763	0.6322	0.6688	0.6237	0.7038	0.7569	0.6312	0.6511	0.7307	0.6879	0.7299	0.6776	0.7092	0.7201
C-HA10	0.6360	0.5990	0.6184	0.5768	0.6039	0.5687	0.6284	0.6784	0.6248	0.5447	0.6716	0.6195	0.6564	0.6103	0.6508	0.6628
C-HA11	0.6801	0.6604	0.6815	0.6251	0.6696	0.6276	0.7016	0.7491	0.6956	0.6480	0.6637	0.6889	0.7307	0.6628	0.7069	0.7193
C-HA12	0.7038	0.6732	0.6945	0.6521	0.6919	0.6430	0.7123	0.7670	0.7091	0.6612	0.7447	0.6362	0.7450	0.6776	0.7053	0.7338
C-HA13	0.7068	0.6776	0.6934	0.6482	0.6904	0.6348	0.7110	0.7657	0.7079	0.6599	0.7433	0.7013	0.6772	0.6736	0.7054	0.7324
C-HA14	0.7293	0.6963	0.7141	0.6588	0.7106	0.6509	0.7320	0.7853	0.7259	0.6769	0.7621	0.7031	0.7621	0.6387	0.7380	0.7540
C-HA15	0.7007	0.6690	0.6872	0.6343	0.6728	0.6275	0.7047	0.7586	0.6987	0.6513	0.7206	0.6764	0.7340	0.6633	0.6440	0.7271
C-HA16	0.7120	0.6755	0.6967	0.6605	0.6795	0.6250	0.7146	0.7692	0.7086	0.6762	0.7416	0.6876	0.7440	0.6744	0.7049	0.6726

The value for the causal diagram is obtained (D + R) and (D-R) and shown in Table 8.

Table 8. Values for the causal diagram.

	Di			**Ri**			**Di+Ri**			**Di-Ri**			**Crisp Di+Ri**	**Crisp Di-Ri**
	l	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**	**l**	**m**	**u**		
C-HA1	0.7865	2.3754	10.6020	0.8219	2.4409	10.6942	1.6084	4.8163	21.2962	-9.9077	-0.0655	9.7801	7.4845	**-0.0734**
C-HA2	0.6357	2.0659	9.7961	0.6891	2.1950	10.1616	1.3248	4.2609	19.9577	-9.5259	-0.1291	9.1070	6.8647	**-0.1523**
C-HA3	0.6053	2.0391	9.6681	0.7634	2.3318	10.4412	1.3686	4.3709	20.1093	-9.8359	-0.2927	8.9047	6.9706	**-0.3208**
C-HA4	0.6249	2.0755	9.8886	0.6143	2.0564	9.8343	1.2393	4.1319	19.7229	-9.2094	0.0191	9.2742	6.7284	**0.0038**
C-HA5	0.6883	2.1934	10.2305	0.7340	2.2485	10.3966	1.4223	4.4419	20.6271	-9.7083	-0.0551	9.4965	7.1040	**-0.0798**
C-HA6	0.7154	2.2433	10.6334	0.5821	1.9955	9.6379	1.2975	4.2388	20.2714	-8.9226	0.2477	10.0513	6.8942	**0.2898**
C-HA7	0.8205	2.4385	10.8986	0.7390	2.2872	10.7361	1.5596	4.7257	21.6347	-9.9155	0.1513	10.1596	7.4653	**0.1013**
C-HA8	0.6675	2.1542	10.1811	0.9520	2.6826	11.6417	1.6194	4.8368	21.8227	-10.9742	-0.5285	9.2291	7.5758	**-0.5656**
C-HA9	0.8040	2.4078	10.9438	0.8113	2.4215	10.6369	1.6153	4.8293	21.5807	-9.8329	-0.0137	10.1325	7.5354	**0.0175**
C-HA10	0.6468	2.1158	9.9505	0.6052	2.0387	10.1036	1.2520	4.1546	20.0542	-9.4569	0.0771	9.3453	6.7966	**0.0093**
C-HA11	0.8871	2.5618	10.9109	0.9245	2.6316	11.2241	1.8116	5.1934	22.1350	-10.3370	-0.0698	9.9864	7.8864	**-0.1082**

C-HA12	0.9704	2.7169	11.1506	0.7345	2.2785	10.5225	1.7049	4.9954	21.6731	-9.5521	0.4384	10.4161	7.6732	**0.3519**
C-HA13	0.7989	2.3982	11.1290	0.9143	2.6124	11.2279	1.7132	5.0107	22.3570	-10.4290	-0.2142	10.2147	7.7816	**-0.1691**
C-HA14	0.9173	2.6178	11.4387	0.7084	2.2302	10.3018	1.6257	4.8480	21.7405	-9.3845	0.3876	10.7303	7.5725	**0.3926**
C-HA15	0.8528	2.4981	10.9703	0.7892	2.3806	10.8348	1.6420	4.8788	21.8050	-9.9820	0.1175	10.1810	7.6048	**0.0757**
C-HA16	0.8794	2.5481	11.1423	0.9174	2.6183	11.1395	1.7968	5.1664	22.2818	-10.2601	-0.0702	10.2249	7.8870	**-0.0632**

Based on the (D-R) values cause and effect relationship is established among the factors. The impact results are shown in Table 9

Table 9. Impact results of factors.

Factors	D+R	D-R	Impact
C-HA1	7.4845	-0.0734	*Effect*
C-HA2	6.8647	-0.1523	*Effect*
C-HA3	6.9706	-0.3208	*Effect*
C-HA4	6.7284	0.0038	Cause
C-HA5	7.1040	-0.0798	*Effect*
C-HA6	6.8942	0.2898	Cause
C-HA7	7.4653	0.1013	Cause
C-HA8	7.5758	-0.5656	*Effect*
C-HA9	7.5354	0.0175	Cause
C-HA10	6.7966	0.0093	Cause
C-HA11	7.8864	-0.1082	*Effect*
C-HA12	7.6732	0.3519	Cause
C-HA13	7.7816	-0.1691	*Effect*
C-HA14	7.5725	0.3926	Cause
C-HA15	7.6048	0.0757	Cause
C-HA16	7.8870	-0.0632	*Effect*

In order to obtain the digraph and to eliminate minor effects, the threshold value (α) is calculated using Eq. (7),

$$\alpha = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}\left[t_{ij}\right]}{N} = 1.9192 \quad (6)$$

A Network Relationship Map (NRM) was established, based on the value of α (1.91). This presented the significance or strength of the relationship, which are shown in the digraph with an arrow (Figure 3). The values that were more than the threshold value of 1.51 are included in the total relation matrix, see Table 8. A Network Relationship Map (NRM) was established.

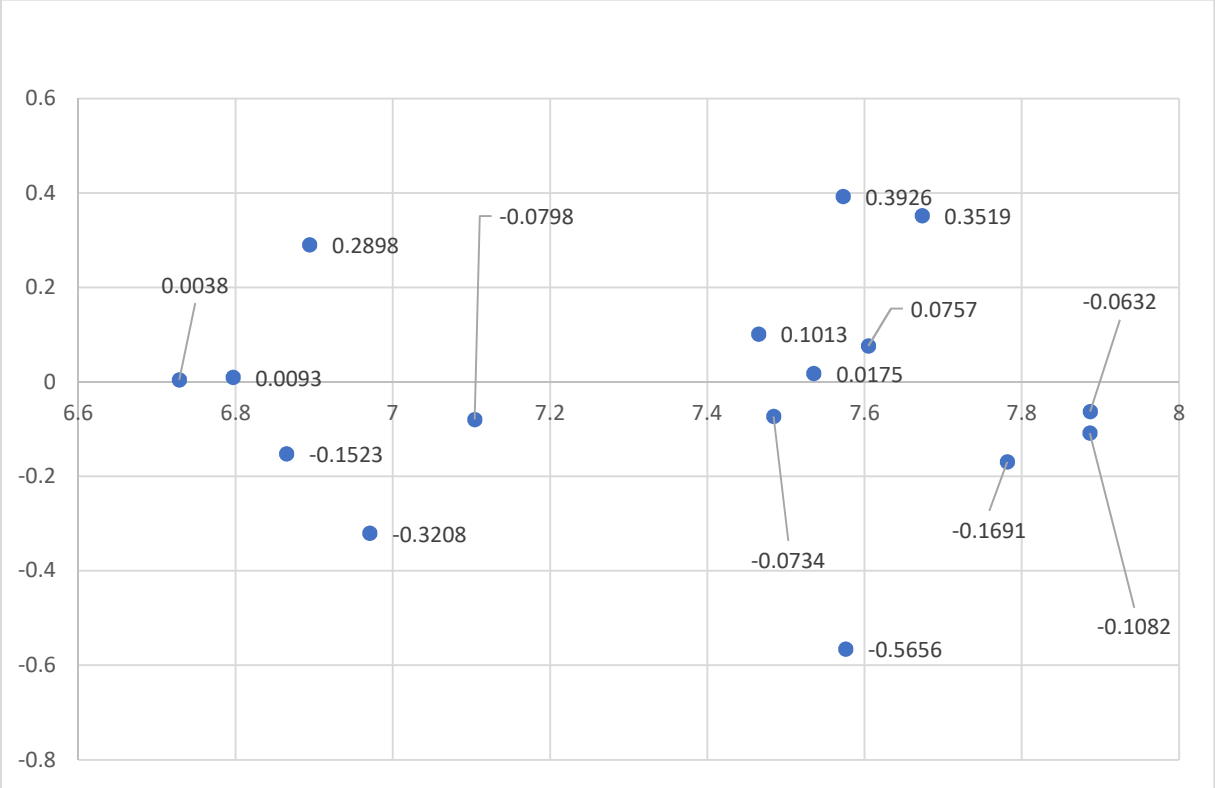

Figure 3. Cause and Effect Relationship.

5. Discussion of Findings

The study explored the key factors that needed to be focused on during pandemics to enhance the operational Effectiveness of humanitarian activities (HAs). These critical factors are grouped as causal factors where D-R values are positive, shown in Table 8. The results imply that these causal factors drive the other factors in the system. On the basis of the values of D-R, the factors are categorized into two groups: Cause and effect. The causal factors include Risk Communication and Community engagement (C-HA4), Agile and Adaptive Governance (C-HA6), Information system (C-HA7), Prevention and Control (C-HA9), Maintaining Essential Heath Services (C-HA10), Preparedness and pandemic response practices (C-HA12), BlockChain enabled Digital Humanitarian Network (BT-DHN) Design (C-HA14), Human security (C-HA15). The causal group factors are elaborated in the following section.

From Table 9, it is visible that BlockChain enabled Digital Humanitarian Network (BT-DHN) is the most significant factor during the pandemic. Pandemics or disaster is highly complex and develops a challenging environment for humanitarian organizations [19]. Intervening during a disaster needs an in-depth understanding of the situation and the context. Social networking sites and social media are used by the people extensively in the front lines of disaster or directly affected to call for help, search for information, share photos, videos and text about their personal experiences and communication about safety to their families and friends. People use different digital channels for sharing real-time data to communicate about recent updates [96]. Digital innovation and technologies offer opportunities to save more lives and explore better ways to communicate to meet the needs of affected people during the crisis. BlockChain enabled Digital Humanitarian Network (BT-DHN) develops participative management and provides real-time information flow to employ uses big data for the humanitarian response for effective relief operations. This new way of humanitarian aid is a cost-effective, attractive and value-neutral way of addressing the needs of those experiencing fragility [2]. This factor regu-

larly encompasses the uses of mobile phones, social media, crisis mapping, crowdsourcing, digital payment systems and geospatial technologies. The technological innovations have brought BlockChain enabled Digital Humanitarian Network (BT-DHN) recently to provide support to the people who are the sufferers of natural disaster or pandemic situation [97] and acts as a liaison between the different digital HOs to work on a project. Table 9 shows that the preparedness and pandemic response practices factor (C-HA1) has received the second-highest weightage (0.3519), indicating the importance of this factor in the pandemic situation. Unlike regional events such as hurricanes, earthquakes, or terrorist attacks, a pandemic is a recurring worldwide occurrence with global implications. Pandemic outbreaks highlight the critical significance of effective planning and response to minimize the mortality rate, social and economic disruptions, and organizational risk. The preparedness and pandemic response practices must include the ability to react immediately, faster and adaptive to the changing scenarios with the changing phase of the pandemic [87]. During a pandemic, global supply chains, as well as local supply chains, need to develop and implement planning and response to assess the organizational performance and consider improvements in the light of an event. This factor including planning, testing and regular reviews that can enhance the organizational Effectiveness of HOs and may place them in a better position to reduce or mitigate the impact of global disruption. It will also provide vigilance, resiliency and an effective roadmap to direct future activities, which may include an action plan for pandemic planning and response. The third most important factor is Agile and Adaptive Governance (C-HA6) which is required during pandemic times. This is in line with the previous research study on agility in the humanitarian supply chains conducted by Dubey et al.[2] which empirically proved the significance of agility for HSC and HAs. Moreover, the impact of information systems has been revealed in the study too. The current study has a similar direction for managing HSCs that justifies the fourth important causing factor, i.e. Information system. The information related to the causes of spread needs to be communicated at a wider level through the stakeholder's participation [98]. The community needs to be empowered with the recent updates, causes, precautions, vaccine (if available), helpline numbers, medical supplies etc. The pause to the spread can be achieved through this factor. From the results, the factors Multi-modal transportation (C-HA1), Leadership during Pandemic Crisis (C-HA2), Empowering the Stakeholders (C-HA3), Information resource orchestration (C-HA5), Capacity building of stakeholders (C-HA8), Inter-organizational coordination and collaboration (C-HA11), Surveillance for Vulnerable Groups (C-HA13), Societal response (C-HA16) are categorized as effect group factors.

The previous studies have suggested that effective HSCs are dependent on the people who lead the operations during the pandemic. The role of the leader who initiates and bind the HOs are the game-changer during an emergency situation. The transportation has to be with multiple modes as the essentials, and the healthcare supplies need to be supplied on time, and thus all humanitarian operations and their Effectiveness are dependent on transportation and logistics, coordination among the stakeholders such as government, people, NGOs, private organization etc.

6. Implications

This paper provides insights for decision-makers, policymakers and stakeholders to consider the critical factors for implementing strategic actions during COVID-19 pandemic disruption. The increasing engagement of the humanitarian organizations with stakeholders is an extremely positive indicator. The HOs need to work more strategically with other partners, as these may become larger stakeholders in international humanitarian response. The humanitarian system will be more structured, agile, prepared than it was before. The paper has explored the factors to be considered for developing a 'new normal' environment, which is more prepared for dealing with the pandemic situation. The BlockChain enabled Digital Humanitarian Network (BT-DHN) will act as a base for partnerships and enhancing the Effectiveness of HAs. Due to the increasing number of

technological advancements at the end of Humanitarian organizations users, offer an opportunity for extending BlockChain enabled Digital Humanitarian Network (BT-DHN) for detecting physical activity, speech and auditory context, location tracking etc. The individuals can directly engage in pandemic response activities using a combination of cloud, crowd and SMS technologies. With the Internet of things (IoT) technology, the sensor data will match or even outgrow social data soon. This will have a strong impact on the humanitarian efforts. Moreover, satellite imagery can help the delivery of aid in the affected areas. The humanitarian sector needs to connect the data across preparedness, response and recovery in a pandemic situation. The humanitarian organizations cannot alone achieve the objectives. Thus, collaboration with the private sector is a necessity. The pandemic has created a need of an alliance between the private and public sectors to transform the humanitarian supply chains.

7. Conclusion and Limitations

With the continuous spread of coronavirus pandemic across the world, disruptions and falling economies, the catastrophic impact on the crisis-affected population is highly visible. Stretched aid budgets in the humanitarian sector present enormous challenges. The lessons from the COVID-19 have made the organizations to be prepared for the 'new normal' situation. Mobile technology is aiming to reach seven million people to use life-enhancing mobile-enabled services during disaster preparedness, response and recovery by 2021. The delivery and impact of assistance by catalyzing partnerships and innovation for new digital humanitarian services advocating for enabling policy environment are to be accelerated. With the help of this paper, we have explored the critical factors to be considered for enhancing the operational Effectiveness of humanitarian organizations during the pandemic. This research approach is certainly in line with the increasing trend towards pandemics and new normal situations. The results of this study show BlockChain enabled Digital Humanitarian Network (BT-DHN) (C-HA14) and preparedness, and pandemic response practices (C-HA12) are the most critical factors that should be considered to increase the operational Effectiveness of HAs during the pandemic. The policymakers and stakeholders will be benefitted by exploring the strength of factors in enhancing the efficiency of HAs to combat the COVID-19 endemic.

This research study has some limitations that are required to be highlighted for future similar studies to consider. The identification and finalization of factors are very challenging. The dynamic environment will develop more factors to be considered for the HOs. Thus, the study has identified sixteen critical factors which may change in future. The study has assessed the factors based on experts from one country, and thus the study may be generalized and replicated to the developing countries only which have a similar condition. The study has investigated the cause-and-effect group developed in the current study that needs to be investigated further with empirical analysis. Furthermore, various perspectives on designing and developing business models for circular economy and their integration with blockchain technology can be extended and empirically developed from the viewpoint of sustainable Humanitarian systems.

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