The characteristics and functionalities of citizen-led disaster response through social media: A case study of the *#HenanFloodsRelief* on Sina Weibo

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ABSTRACT

Using the topic of *#HenanFloodRelief* on Sina Weibo during the 2021 Henan floods as a case study, this research adopts a combination of social network analysis, content analysis, and text analysis to explore the characteristics and roles of public participation in disaster response through social media. The findings show that under the *#HenanFloodRelief* topic, the public was mainly involved in emergency response by posting help and rescue information, updating disaster information, and providing contact details for resource coordination. They also expressed emotions to reflect post-disaster social psychology, providing an emotional basis for social mobilization. Public and organizational participation demonstrated different characteristics, exhibiting the advantages of spontaneity and firsthand information. In contrast, organizational participation reflected professionalism and played a more significant role in providing emotional comfort and mobilization. The research demonstrates the vital role of social media in enabling public participation in disaster response while pointing out the potential risks of the public utilizing information resources for online relief efforts, highlighting the need for further research into effective information verification methods. This study provides a Chinese case to examine public participation in disaster response and offers insights into this field of research.

1. Introduction

Natural disasters often threaten people's lives, property, and social security. Therefore, taking reasonable and timely emergency measures is necessary. In traditional perspectives, the main actors in disaster response are typically community, social organizations, and government agencies with clear regulatory structures. Disaster response activities also exhibit characteristics of organization and regulation. Besides, within this framework, some citizens may participate in emergency processes as volunteers or spontaneously [1]. Furthermore, in recent years, the role of citizens in emergency response has gained a lot of attention [2–4], and there has been an increasing call for citizen participation in leading emergency response efforts [5,6]. NEEDS conference in Copenhagen in November 2022 affirmed the necessity of citizen participation in disaster emergencies and emphasized the significance of citizen involvement in disaster response.

Traditionally, citizen participation in disaster emergencies has mainly involved search and rescue, transporting and distributing relief supplies, and providing food and drink to victims and emergency workers [1]. With the development of the Internet and the rise of social media, the digitalization of society has become increasingly prevalent. In this context, online platforms represented by social

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media have also become involved in disaster emergencies and have become virtual channels for citizen participation in disaster response [7,8]. Specifically, the citizens utilize social media to exchange and share real-time disaster information, requests for assistance, information about relief supplies, and other relevant content, actively participating in the emergency response process. As a result, a new online space is available for disaster response.

From the perspective of online emergency response, information plays an essential role in citizen participation in disaster emergency and rescue. Existing research suggests that utilizing information resources to participate in disaster emergencies has excellent potential and serves as a bridge between the confidentiality of official emergency response information and the information needs of the public [8]. Regarding the roles played by the public in online disaster emergency response, they are generally classified into five categories: Citizens, Sensors, Trusted Sensors, Nodes, and Agents [7]. The specific roles of citizens in participating in online disaster emergency response mainly involve rescue operations, coordination, and information compilation [8].

Although the necessity and significance of citizen participation in disaster emergencies have been recognized, from a global perspective, the issue of citizen participation in disaster emergencies still needs to be emphasized. China is prone to frequent disasters and has 1.067 billion internet users [9]. Thus, the participation of citizens in emergency response through the Internet during disaster events is of concern. Among the significant natural disasters in China in recent years, the Henan rainstorm event in July 2021 has received widespread attention. China's meteorology community called it the "21–7″ Henan extreme rainstorm. In total, 14.786 million people were affected by the floods and secondary disasters it triggered in Henan Province, with 398 people dead or missing [10,11]. During this period, the representative user-based social media platform in China, Weibo, witnessed the spontaneous creation of the topic #HenanFloodsRelief (#河南暴雨互助) and became a prominent topic on the Internet due to diverse participants, the high volume of discussions, and high popularity. Therefore, this study focuses on the following research questions, taking the topic of # HenanFloodsRelief as an example.

2. Literature review

2.1. Disaster response: from offline to online development

Human livelihood and production are facing increasingly severe challenges under the threat of disasters, and the risk of natural disasters has become an essential factor constraining sustainable development. Once a disaster occurs, it has a significant negative impact on individuals, society, and the entire nation [12]. Therefore, the importance of disaster response cannot be overlooked. Dealing with disasters is generally divided into three stages: the preparation stage before the disaster occurs, the response stage which is the emergency response after the disaster occurs, and the recovery stage which is the medium and long-term recovery stage [13]. This article focuses on disaster response, specifically the response phase of handling disasters, and does not pay more attention to the other two stages. In past practices, emergency response measures for natural disasters mainly include issuing response measures and public preventive measures, transferring disaster-affected people, providing and transporting relief supplies, handling the aftermath of the deceased, organizing self-rescue and mutual rescue of disaster-affected people, etc. [14]. These processes involve multiple rescue links, mainly supervised and controlled by the central government throughout disaster support and disaster management [15], and mobilize several other participants for offline disaster response.

Crisis informatics, which emerged in response to crises, is founded on the core principle that individuals use personal information and communication technologies creatively to manage disasters and cope with uncertainty [16]. This principle succinctly captures the overall characteristics of online disaster response. Existing research has found that a critical reason limiting disaster relief emergency response is the perception and transmission of the disaster situation. Existing research has found that an essential reason that constrains disaster relief emergency response is the perception and transmission of the disaster situation. Therefore, real-time disaster information acquisition and analysis have become vital links in disaster emergency response [17], and the significance of online disaster response has garnered increasing attention. Some scholars have questioned the applicability of the general tool for responding to various emergencies, namely the Incident Command System (ICS) [18], and proposed more effective emergency response methods. Takahagi et al. [19] introduced the Disaster Information Transmission Common Infrastructure System (DITCIS) to digitize disaster information. Such systems can instantly share and register massive disaster information and automatically transmit disaster information to residents and various disaster communication tools. However, the Chi-Chi earthquake in Taiwan and Hurricane Katrina in the United States have shown that current emergency response systems based on telephones, radio, and television cannot meet residents' and responders' information-sharing and communication needs during significant disasters [19,20]. Therefore, based on the characteristics of being instant, bidirectional, and having a large scale of influence, Internet and social networking tools have become a solution for disaster emergency response. Research on social media and its characteristics in disaster response also plays a dominant role in crisis informatics [21]. Using social media can improve the efficiency of relief material airdrops and significantly impact the acquisition of relief materials [22]. Tim et al. [23] believe that social media possess different boundary-spanning competences, facilitating cross-boundary response actions in disasters across information, communication, and relational boundaries. From a global perspective, transnational organizations can utilize social media for crisis communication and distributed work, creating communities on a global scale to help address social issues arising during disasters [24].

Wenger et al. [25] believe that a comprehensive emergency response process should include collecting and distributing emergency information, rational allocation and role of personnel, sufficient human resources and materials, professional response organization coordination, and effective interaction between the government and social media. The role of social media in facilitating the online integration of disaster information from various sources is becoming increasingly prominent [26]. Response organizations and citizens are trying to carry out meaningful cooperation online and onsite [27], thus forming a more flexible organizational configuration. During a disaster, people can find helpful information through social media platforms, provide firsthand disaster reports, and

seek help from the government [28,29]. First responders and relief agencies can thus determine the urgent needs of the affected population, confirm emergencies, and allocate offline rescue resources and actions accordingly [30].

2.2. Citizen disaster response and organizational disaster response

The complexity of disaster relief efforts stems from the rapid influx of many relief organizations under extremely tight time and resource constraints [31]. Responding entities include government departments, non-governmental organizations (NGOs), volunteer groups, and the public and media [2]. The government is the primary entity in emergency management, taking on the responsibility of social administration, ensuring public safety, centralizing emergency resources, and intervening in the role division of other organizations through its significant influence [31]. Social organizations act swiftly at the onset of a crisis, mobilizing professional rescue teams for emergency aid, rallying societal forces to supply disaster relief materials, and actively mobilizing organizational teams for emergency response [32]. At the same time, social organizations assist the government in various aspects of emergency response, including integrating and deploying emergency resources, thereby improving the efficiency of societal resource utilization and enhancing the overall effectiveness of the emergency response.

Historically, disaster management paradigms were rooted in scientism and expertise, excluding non-professional citizens and stakeholders from disaster prevention and response activities. Scholars have long pointed out the importance of the public's role in collaborative disaster governance. In crisis and disaster situations, citizens emerge in response to the suddenly increased demand [33], collaborating with official organizations to manage crises such as earthquakes and floods through volunteer service. The public offers advantages in disaster response, such as large numbers, rapid response, and broad rescue coverage, complementing the strengths of the government and serving as an indispensable force in disaster governance. The diversity of citizen disaster responses was observed in events such as the 2015 South Indian floods [34] and the Nepal earthquake, where citizens became increasingly and profoundly involved in disaster responses.

Today's complex and dynamic disaster response system encompasses both the formal disaster responses of institutionalized organizations (including government agencies and humanitarian aid institutions) and the participatory disaster responses of citizen volunteers. Some practitioners and scholars have shown interest in collaboration between formal response organizations and online communities. Park and Johnston's research aptly explains how citizen and organized disaster responses relate, where resource dependence, shared understanding, and information technology become vital factors. This study proves the cooperation and interdependence between the two parties from another perspective [35]. With the proliferation of the Internet and mobile technologies, social media has enhanced crisis management [36], a change reflected in citizen and organizational disaster responses. Traditional disaster response systems of the government and related social organizations relied on formal networks and centralized information flows, making it hard to grasp unfolding local situations. Organizations face challenges decisively acting when information is dispersed across various local sources [37]. In contrast, public disaster responses excel at handling local, dispersed information and acting swiftly. Scholars have largely agreed on the mainstream idea of multi-stakeholder participation in disaster governance, where diverse entities collaborate to achieve shared disaster reduction goals, forming a cooperative relationship through information dissemination and resource sharing.

2.3. The role of citizens in disaster response

In traditional disaster response, the potential for citizen participation was perceived as immense. They converged on disaster sites, assisting in damage assessments, providing shelter, partaking in search and rescue operations, and offering broader support to professional responders [38,39]. For instance, Following the 2015 Nepal earthquake, some restaurant owners took the initiative to participate in the relief efforts by transporting supplies, and others provided free meals to those stranded at the airport [40]. With advancements in information and communication technologies, avenues for public participation in disaster governance have expanded, extending the role of the public in disaster and emergency responses. In recent crises induced by natural disasters and human conflicts, many individuals worldwide have utilized social media and information and communication technology (ICT). Not only do they use it as a source of information [41], or to share their own disaster experiences, but they also help each other [42]. Scholars have termed individuals using these communication technologies "digital volunteers" [43,44]. These loosely connected individuals are referred to as "participatory online groups" [45], also considered "quasi-organized groups." The digital volunteers' network and organizational structure are predominantly agile, fluid, and flexible [46], engaging online with pressing issues of common concern when the issues are not typical and need to be addressed in parallel, the crowd organizes into many smaller groups [47]. The voluntary response activities of these digital volunteers typically encompass transmitting, amplifying, synthesizing, or constructing information during disasters [48] and "crowdsourcing" [49]. Specifically, they collect real-time disaster-related data from mainstream media and social media, as well as official situation reports, and participate in rescue efforts using mutual aid documents and online rescue channels. Their endeavors significantly enhance situational awareness of disaster conditions and enable public institutions and humanitarian relief agencies to respond effectively to incidents [50]. Such voluntary response efforts are vital resources for effective and timely disaster response.

Citizens in the disaster response process are not isolated entities but are closely linked with other organizations. Reuter et al. have noted that within the crisis communication matrix, the use patterns of Authorities to Citizens (A2C) and Citizens to Authorities (C2A) can be utilized to explain the interactions between government and citizens during a crisis [51]. This interactive function is realized through social media, which significantly facilitates effective collaboration between the two parties by making actions and actors visible, thus promoting sharing and communication [52]. Users use social media platforms to convey their feelings and needs regarding the value of information. By studying public information, governments and rescue agencies can formulate accurate and timely disaster guidelines and suggestions [53]. In the disaster response to the 2021 Henan floods, civilian rescue organizations used an online

form on Tencent Docs titled "Information of People Awaiting Rescue" to collect rescue information. This form evolved from a simple request form into a "multi-purpose" civilian flood-fighting resource coordination platform. Relevant disaster information played an essential role in assisting official rescue organizations to adjust and control the evolution of the disaster event [54].

Despite the ability and willingness of the public to take on disaster response responsibilities, numerous issues are exposed due to their lack of professional training. They cannot address these problems as they often receive no coordinated assistance [55]. For response organizations, consider the issues of citizen convergence [56] and the accountability (who is responsible for the harm?) and legitimacy (who do the volunteers "belong" to?) of volunteer aggregation [56]. Authorities consider spontaneous volunteers a risk and a burden [57], hence incorporating citizens into response actions remains a challenge [58]. Moreover, the material limitations of mobile devices make them prone to power outages or malfunctions due to weather conditions [59], hindering the rescue process. However, recent research has revealed that these limitations are accepted and solvable. Official agencies are increasingly embracing digital volunteers, and beyond assistance in actual rescue work, Appleby-Arnold et al. found that social media and disaster-specific applications are not only valuable tools for communication between citizens and authorities but can also help build, rebuild, or strengthen trust between authorities and residents [60]. Additionally, the challenges of communication devices can be eliminated by continuously developing and upgrading technological means. Furthermore, by enhancing research related to disaster citizen science, it is possible to improve system response capabilities and generate relevant data to mitigate adverse health effects [61].

The literature reviewed reveals an evolving landscape of disaster response, with citizens taking on growing roles through social media and digital platforms. However, key questions remain regarding citizen participation in disaster response discussions online. This study aims to address these gaps by examining.

Q1. Who are the main contributors of disaster emergency-related posts on this topic, citizens or organizations? And what is the content distribution in both entities?

Q2. What is the role and positioning of the citizens and organizations as contributors in the posts related to disaster emergencies?

Q3. What are the specific functions of citizen participation in disaster emergency response in the content of posts under the topic? Are these functions distinct from those of organization participation, and what characterizes these differences?

3. Methods

3.1. Data collection and cleaning

In the context of the Henan rainstorm event, the Sina Weibo platform became the main online space for discussions related to the event due to its openness, large user base, and high activity level. *#HenanFloodsRelief* on Sina Weibo emerged as a core topic, characterized by its openness, participation from multiple users, high volume of discussions, and active engagement. The period of interest for this study was primarily from Jul. 21, 2021, to Aug. 02, 2021. Therefore, we focused on collecting the content of posts under *#HenanFloodsRelief* during this period. Using the Sina Weibo API interface, we obtained 12,001 posts, including information such as the username and ID of the post author, verification status, original text of the post, and timestamp. The verification status was utilized to categorize post authors. On Sina, three types of verification status exist individual verification, organizational verification, and non-verification. This study classified authors with individual verification or non-verification as citizens, while those with organizational verification were categorized as organizations. Citizen posts were submitted through individual accounts, while organization posts were disseminated through official organizational accounts, including government officials' accounts, entrepreneur accounts, social organizations' accounts, and local media accounts. Then, we conducted data cleaning to ensure the quality and relevance of the collected data. Through data cleaning, duplicate, meaningless, pure emoji, non-Chinese, and unrelated to the event were removed, and a final dataset of 10,806 Weibo posts was finally obtained.

3.2. Research procedure

The research procedure for this study is illustrated in Fig. 1. The study utilizes the collected samples for semantic analysis and content analysis to examine the network structure and specific characteristics of citizen participation in the disaster response on Sina Weibo during the Henan rainstorm. Firstly, to investigate the differences between citizen-led and organization-led emergency responses, this study categorized the samples into two parts based on the text publishing entities: posts published by citizens (Sample 1) and posts published by organizational entities (Sample 2).

Secondly, for semantic analysis, the study employs social network analysis to construct a keyword co-occurrence matrix of the samples. A network graph of keyword co-occurrence is visualized, and the semantics are interpreted using measures such as degree centrality and Quadratic Assignment Procedure (QAP) analysis. Thirdly, for content analysis, this study establishes seven categories, including resource mobilization, resource provision, social mobilization, emotional expressions, rescue actions, scientific popularization, and information verification, based on existing literature and the actual content of the samples. The Divominer is utilized to automatically code Sample 1, enabling further exploration of the specific characteristics of citizen-led responses on social media.

3.2.1. Network semantic analysis

Social network analysis is used to interpret the semantics of the samples, which involves the following steps.

(1) Using ROST-CM6 software, construct keyword co-occurrence matrices for Sample 1 and Sample 2 separately.
(2) Use Gephi software to visualize keyword co-occurrence networks for Sample 1 and Sample 2.
(3) Use UCINET 6 software to calculate the degree centrality of the keyword co-occurrence matrices for Sample 1 and Sample 2.
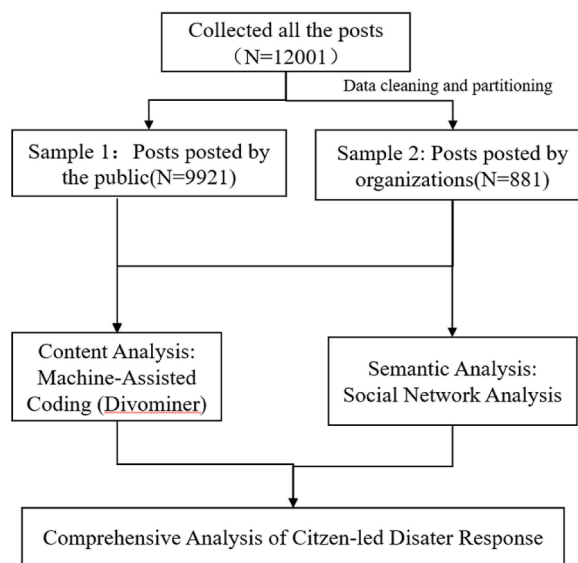
Fig. 1. Research procedure diagram.

(4) Use UCINET 6 software to calculate the correlation (Quadratic Assignment Procedure, QAP) between the keyword co-occurrence matrices for Sample 1 and Sample 2.

Step 1 involves constructing the keyword co-occurrence matrices by counting the times two words appear together in the same Weibo post. Steps 2, 3, and 4 are performed independently based on the resulting matrices. Step 2 visualizes the network graph of word co-occurrence, where nodes represent words, the size of nodes means their importance, and edges between nodes represent associations between words. Each word in the matrix has a degree centrality value, which indicates its centrality within the network. Step 3 calculates these values. Step 4 compares the semantic similarity of the two matrices for Sample 1 and Sample 2, analyzing their semantic similarity. These four steps help researchers interpret and identify keywords or central words in the samples from the perspectives of visualization, degree centrality, and QAP, thus capturing the core semantics of the samples.

3.2.2. Content analysis

Previous studies have shown that information collection (including information about seeking help and providing help), information verification, and information coordination play an essential role in online rescue practice [62]. Furthermore, emotional expression and social mobilization are also crucial in emergency response [63]. Based on these, this study determines the coding categories combining the actual content of the text (Appendix Table 1).

In the content-coding phase, this study utilized the Divominer platform, which combines artificial intelligence algorithms and big data technology for machine-based automatic coding. Determining keywords and content coding in this study's coding categories were performed interactively to improve coding accuracy. The steps were: (1) Determination of the preliminary coding book. During the primary research phase, researchers read many rescue texts and conducted multiple rounds of discussions to summarize and compile a list of keywords for each category, forming a preliminary coding book. (2) Reliability testing, refinement of the coding book, and execution of machine coding. This research drew a random 1% sample, equivalent to 120 texts, from the coding library for manual coding, following the methodology of the previous study [64]. Two researchers followed the instructions in the coding book to ensure the accuracy of keywords and the consistency of their understanding of the coding book. The Holsti index was used to calculate the manual coding reliability, which showed good reliability with a value of 0.81. The keyword list was adjusted and revised based on specific testing situations to optimize the coding book further. After reaching a consensus on the coding standards and finalizing the coding book (Appendix Table 2), Divominer implemented machine-based automatic coding for all the data. (3) Checking the reliability of machine-based automatic coding. A random sample of 1% of the total data (120 posts) from Weibo texts was manually coded and compared with the results of machine coding to ensure the accuracy of automatic coding on a large scale. Based on the reliability test provided by Divominer, the Holsti index for coding reliability was 0.78, indicating good reliability.

4. Results

4.1. Semantic analysis

4.1.1. Semantic network

Fig. 2 shows the co-occurrence of keywords in posts released by organizations in the *#HenanFloodsRelief* topic. Keywords like "Henan" and "Rescue" are in the central position, indicating greater attention and impact. Other words include "Heavy Rain," "Zhengzhou," "Firefighting," "Relief," and "Supplies." are in the secondary central positions. Furthermore, the keywords "Henan,"

Table 1
Analysis of degree centrality of core keywords in the semantic networks.

Organizational Semantic Network			Citizen Semantic Network	
No.	Keywords	Centrality (standardized)	Keywords	Centrality (standardized)
1	Henan	82.600	Rescue	418.286
2	Rescue	69.514	Contact	227.600
3	Heavy Rain	41.857	Xinxiang	194.771
4	Zhengzhou	33.343	Heavy Rain	119.686
5	Firefighting	20.571	Henan	117.943
6	Flood Control	17.686	Supplies	90.000
7	Relief	15.229	Seeking Help	85.514
8	Supplies	11.943	Urgent Need	80.143
9	Crowd	10.771	Verify	71.971
10	Members	7.457	Xinxiang City	60.229
11	Serious	7.314	Zhengzhou	57.314
12	Scene	7.029	Volunteers	48.657
13	News	6.914	Cell Phone	30.943
14	Xinxiang	6.371	Friends	26.114
15	Zhengzhou	6.343	Spread	24.400
16	Hours	6.286	Help	23.714
17	Waterlogged	6.029	Henan Province	23.686
18	Force	5.800	Weihui	23.543
19	Detachment	5.286	Elderly	21.743
20	China	5.200	People	20.886
21	Emergency	5.171	Muye	20.686
22	Safety	4.686	Support	20.229
23	Henan Province	3.943	Signal	19.571
24	Firefighters	3.829	Emergency	18.457
25	Assistance	3.714	Request	15.400
26	Response	3.229	Nearby	13.657
27	Disaster	3.086	Fengquan District	13.571
28	Rainfall	3.029	Mayday	13.229
29	Transfer	2.943	Severe	7.829
30	Rush	2.886	Location	7.657
31	Cheering	2.257	Water Level	7.514
32	Recovery	1.857	Cheering	7.371
33	People	1.743	Help	7.343
34	Impact	1.343	Neighborhood	6.571
35	Time	1.343	Da Dao	5.914
36	Contact	1.343	Child	5.857

Table 2
Correlation and regression analysis of the two semantic networks.

	QAP correlation	MR-QAP regression
Obs Value	0.756*	0.591**

*P = 0.000 < 0.001 **P = 0.000 < 0.001.

"Rescue," "Heavy Rain," and "Zhengzhou" have slightly higher contribution and influence than "Firefighting," "Relief," and "Supplies." The keywords like "Scene," "Safety," and "Cheering" appear in the second layer of the graph.
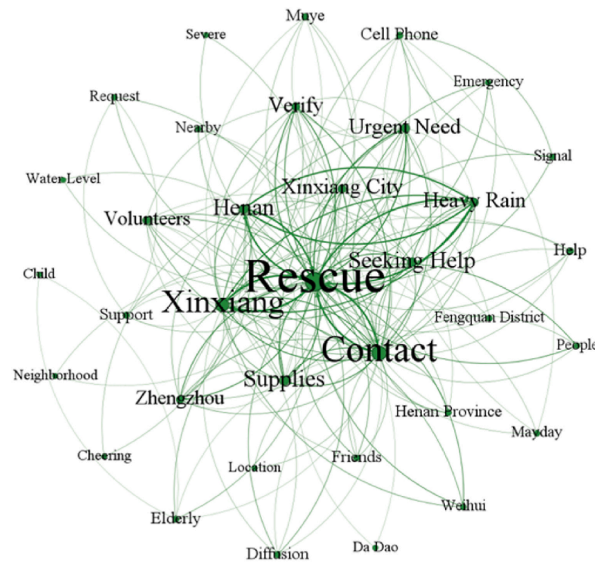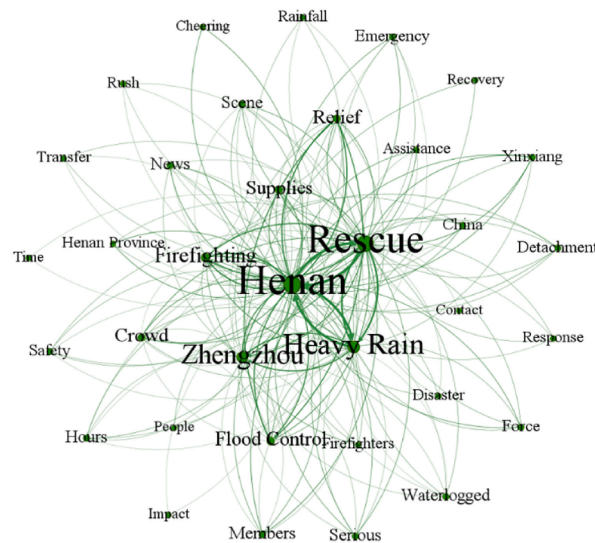
Overall, the posts released by organizations focus on the progress of the rainstorm disaster, particularly the situation in Zhengzhou, as well as the disaster scene, flood control information, disaster recovery, and emotional mobilization.

In the network graph of citizens' texts (Fig. 3), the keyword "Rescue" is in the central position, while "Seeking Help," "Henan," "Xingxiang," "Supplies," "Contact," and "Heavy Rain" are in the second central positions. Furthermore, the keywords "Rescue" and "Contact" have slightly higher contribution and influence than "Seeking Help," "Henan," and "Supplies," and Keywords like "Urgent Need," "Volunteers," and "Verify" appear in the second layer of the graph.

The citizens' posts have a concentration of content related to participating in rescue efforts. Words such as "Rescue," "Volunteers," "Verify," and "Supplies" reflect the online emergency rescue activities. The citizens' posts also contain content about specific disaster-affected areas and social mobilization.

The analysis of the semantic network graph reveals that organizational posts primarily focus on disaster situations and rescue operations. In contrast, citizen posts concentrate on seeking help, providing assistance, verifying information, and sharing information. Organizational posts emphasize factual reporting, while public posts highlight direct engagement in emergency actions.

Fig. 2. Semantic network of organization's posts.

Fig. 3. Semantic network of citizen's posts.

4.1.2. Centrality analysis of semantic networks

The study conducted a Degree Centrality analysis on the keyword matrices generated from Sample 1 and Sample 2, revealing the core words of their semantic networks, as shown in Table 1. Sample 2 exhibited a significantly higher centrality for its core keywords than Sample 1. It suggests that the content posted by citizens is more focused and emphasizes core keywords. Regarding content, both samples shared a common focus on heavy rain rescue.

In the semantic network dominated by organizations, flood control information, rescue operations, disaster scenes, and emotional mobilization are more prominent. Regarding the content, the disaster event was primarily caused by heavy rainfall, closely related to flood situations, so flood information drew much attention throughout the emergency response process. Local media is an integral part of organizations. By examining keywords such as "scene," "strength," and "cheering," it can be inferred that the media focused on discovering and disseminating emotionally rich content that evoked feelings of "touching," "sadness," and "inspiration" from rescue scenes, thereby harnessing the power of emotions for social mobilization.

Critical aspects such as seeking help and assistance, resource provision and coordination, information verification, and mobilization are more prominent in the semantic network of citizens. These functions are essential in disaster response and are relevant to rescue operations. Similarly, the semantic network of citizens also includes mobilization-related content, but with notable differences compared to organizational subjects. Unlike organizational subjects, which rely on evoking emotional resonance to mobilize various sectors of society (referred to as "emotional mobilization"), citizens often employ informal and direct appeals such as "Request,"

"Help," "Spread," and "Please" to express their mobilization needs, addressing their resource requirements or appealing to specific recipients. This approach leans more towards call-to-action mobilization.

4.1.3. Relationship between different semantic networks

The QAP analysis results (Table 3) reveal a significant positive correlation of 0.756 between citizen and organizational subjects' semantic networks. The MR-QAP regression analysis indicates that the semantic network of sample 1 has a 59.1% positive influence on sample 2. Considering the semantic network graph and degree centrality analysis, both subjects focus on "Henan Heavy Rain Rescue," emphasizing emergency response to heavy rain. Therefore, there is a high level of relevance between the two networks.

4.2. Content analysis and text analysis

Semantic analysis of the #HenanFloodsRelief topic indicates that the semantic network of the citizens, compared to organizations, better reflects specific emergency response actions after the disaster. The keywords with a high degree of centrality, such as "Rescue," "Supplies," "Seeking Help," and "Contact," demonstrate that the citizens utilizing Sina Weibo engaged in emergency activities, including disaster relief, resource allocation, and information sharing in response to the Henan heavy rain event. Furthermore, this study conducted text analysis on relevant Weibo posts based on the content analysis results (Table 4), aiming to elucidate further the specific emergency response functions carried out by the public and organizations during the heavy rain event.

According to the result of content analysis, resource mobilization is the most prominent emergency function in both entities, though it is more significant in citizens' posts (6552, 66.04%) than organizations' (330, 37.29%). The second most prominent function in both citizen (1,938, 19.53%) and organization (241, 27.23%) response is resource provision and coordination. Similarly, there are a small number of posts about social mobilization and scientific popularization, accounting for 2.47% and 0.20% of citizens' posts and 3.16% and 1.24% of organizations' posts, respectively. As a distinction, 11.64% of organizations' posts are about emotional expression, but its counterpart is only 4.9%. Likewise, 19.32% of organizations' posts showed rescue action information, but 5.79% of citizens' posts acted the same way. As for the verification function, we only collected 111 posts about information verification, but 110 of them came from citizens, and only one post was posted by the organization. This finding shows that information verification's function in the emergency response is fragile, especially in organizations.

The most prominent function is resource mobilization. In this context, the citizens explicitly express specific needs for rescue, material aid, and locating missing individuals. For example: "*Urgently needed in Juxian, Hebi: non-woven geotextiles, permeable membranes, woven bags, flood drainage filters, flood barriers, handheld or head-mounted flashlights, and daily necessities for relocated residents.*" Organizations also explicitly express the need, but their contents tend to be more detailed, showing their expertise. For instance: "*Please disseminate!.. We urgently need materials and supplies: life jackets, raincoats, knee-high rain boots, flashlights, portable searchlights, high-power water pumps, generators, summer coolers, mattresses, and more. Contacts: Wa**, 136********, Do** 138********, Gu** 185********, Wu ** 177********, Weng Yanong 138********. And now, we announce the rescue contacts and contact information for each town (street) as follows: … …*"

Related to resource mobilization are resource provision and coordination. In response to post-disaster resource needs, the citizens promptly share information about available resources that match the demands, providing ways to connect those resources with the affected areas. For example, posts such as "*We currently have three forklifts, one off-road forklift, two power support vehicles, four pumps, and two large off-road vehicles at the intersection of Shihua Road in Shangjie District. We are on standby and can be contacted anytime. Contact person and phone number: Ji**, 199**********" demonstrate this approach of offering resources and facilitating their allocation to ensure effective matching. Additionally, some users are willing to travel to disaster-stricken areas as volunteers and actively participate

Table 3
Content analysis results of citizen emergency response texts.

Categories	Frequency	Percentage
Resource Mobilization	6552	66.04%
Resource Provision and Coordination	1938	19.53%
Social Mobilization	246	2.47%
Emotional expressions	482	4.86%
Rescue Actions	574	5.79%
Scientific Popularization	19	0.20%
Information Verification	110	1.11%

Table 4
Content analysis results of organization emergency response texts.

Categories	Frequency	Percentage
Resource Mobilization	330	37.29%
Resource Provision and Coordination	241	27.23%
Social Mobilization	28	3.16%
Emotional expressions	103	11.64%
Rescue Actions	171	19.32%
Scientific Popularization	11	1.24%
Information Verification	1	0.11%

in post-disaster rescue activities. For instance, a user writes, "I'm *in Hebei with my sisters. We're currently unemployed and want to go to Henan as volunteers to contribute. However, we can't find a channel to register as volunteers. Can anyone provide information?*" Aside from the resource provision information above, organizations in this category tend to share more information coordination services such as rescue applications, contact phone numbers, and donation channels. For example: "*People in need can request help through the 'Flood Prevention Information Assistance Zone' on the 'Tencent Travel Service' mini-program. Users can access this feature by going to 'WeChat - Pay - Travel Services' or searching 'Travel Services' in WeChat and then accessing the 'Tencent Travel Service' mini-program. Here, they can find the 'Flood Prevention Information Assistance Zone' to share and exchange information related to rescue. Flood prevention and rescue departments can export this information in tabular form, making it easier to filter and respond quickly, saving precious time.*"

Besides assisting in specific rescue activities through resource mobilization, provision, and coordination, the citizens also express emotions such as blessings, touched sentiments, and sadness through their posts. For example, posts like "*Tears in my eyes, everyone, keep going, stay strong!*" and "*"Henan, stay strong! Wishing for safety!*" are commonly seen. Organizations also express similar emotions, but their contents are more detailed, longer, prosperous in media forms, and often directly connected to the rescue site. For example, this post "*Residents embrace firefighters, crying with gratitude: On Jul. 26, the Firefighting and Rescue Brigade of Shijiazhuang, Hebei, completed a drainage mission in a residential community. Residents of the community, holding banners, stood on both sides of the road to express their thanks to the firefighters. One resident, overwhelmed with emotion after presenting a banner, rushed forward to embrace a firefighter, shedding tears tightly.*" It was accompanied by a video expressing intense gratitude to the rescue personnel. Similarly, in the posts describing rescue actions, citizens' contributions are more concise and closely tied to their experiences.

In the context of *#HenanFloodsRelief*, ensuring the authenticity of information is crucial for disaster relief. Therefore, under the topic, the citizens have spontaneously started verifying relevant information to eliminate redundant information and interference that could hinder rescue efforts, thus ensuring the effectiveness of information in disaster relief. For example, posts like "*Appeal not to repost rescue information repeatedly. There are many channels for seeking help online now. We should not mindlessly repost rescue information, as it will affect the progress of rescue work. Those who have received help should also delete rescue information promptly!*" can be seen. However, with only one post, organizations' posts lack this kind of content.

Additionally, because the heavy rain might cause some underlying safety hazards or secondary disasters, both entities would share relevant scientific information. For example, posts like "*How to protect yourself during a rainstorm: Be cautious of stagnant water pollution, use mosquito repellent, and maintain cleanliness*" can be found. Similarly, both entities call for attention and participation in disaster relief efforts, thus supporting social mobilization. Posts like "*Urgent notice: Attention to all residents in Xun County! Massive water seepage occurred at the Fu Zhuang embankment. We urgently need a large number of sandbags. Gather immediately, 100 m west of Vienna Hotel, to help fill sandbags and protect our common home!*" demonstrate the mobilization function. Regarding their functions in science popularization and social mobilization, the contents of both entities are pretty similar.

5. Discussion

5.1. Information: functions and risks in post-disaster emergency response

This study indicated that under the topic of *#HenanFloodsRelief*, the citizens primarily participated in emergency response by posting help and rescue information, updating disaster information, providing contact details for resource coordination, and posting social mobilization and science information. Information was vital in facilitating disaster emergency response and rescue efforts in this process. Previous research has indicated the importance of acquiring crucial information after a disaster for emergency response and rescue activities [65,66]. The findings of this study once again confirm the diverse functions of information in disaster emergency response.

Due to its characteristics of openness and accessibility, social media enables a convenient and timely exchange of information, surpassing spatial limitations [67,68]. In the specific case of this event, it was observed that a significant number of the public posted requests for help and rescue information on Weibo, continuously updating and supplementing it. Unlike traditional emergency response situations, social media transcends spatial constraints in disaster emergency response and rescue. Citizens, regardless of whether they are in disaster-stricken areas, can promptly share disaster-related information, leading to a new form of internet-based disaster emergency response and rescue characterized by open participation and spontaneous involvement based on information dissemination and sharing [8,67,69].

However, at the same time, the openness and freedom of information sharing on social media can create obstacles to disaster response, such as information overload, the spread of false information, and the redundancy of ineffective information [70,71]. As disaster events often directly affect personal safety and societal stability, the accuracy of emergency-related information is crucial [72,73]. Considering the concentrated and rapidly spreading emergency information on social media, the importance of information verification, aimed at removing misinformation, is self-evident. Under *#HenanFloodsRelief*, the citizens have demonstrated an awareness of ensuring the authenticity of information while engaging in emergency response efforts and initiating information verification measures. In terms of overall information verification, due to technological limitations, the public mainly relied on posting appeals for users who have resolved issues to delete their posts as a form of verification voluntarily. While volunteers were involved in the traditional sense of "reviewing" information, the proportion of posts that underwent information verification remained very small based on the final presentation of information. Therefore, how to carry out adequate information verification in an Internet emergency is still worthy of consideration and attention [74].

5.2. Emotions: manifestation of post-disaster social psychology and the foundation of social mobilization

Based on the content analysis and text analysis conducted in this study, it is evident that emotional expressions are a crucial element throughout the emergency response event under *#HenanFloodsRelief*.

The posts containing emotional expressions show that the public's emotions are primarily reflected in the following aspects: Firstly, the affected individuals express fear and anxiety towards the heavy rain disaster, along with concerns about receiving timely rescue and proper resettlement. For example, "*Can anyone tell the common people when we will have water and electricity? Even if it's intermittent, it would be fine. Let the people ensure their basic living. What should we do in the current situation?*" Secondly, there are expressions of gratitude and respect towards the rescue forces. Based on the content, expressions of gratitude mainly come from the affected communities, while expressions of respect come from a broader range of users. Thirdly, there are expressions of blessings to the disaster-stricken areas and encouragement to the victims, primarily originating from users outside the disaster areas. For example: "*Thank you, Le Ran, from the University of International Business and Economics. I am truly touched and proud that there are so many amazing people worldwide. I hope everyone's warmth will dissolve all the bad things.*" The public's expression of emotions on social media platforms after a disaster is, to some extent, a reflection of the social psychology within the disaster context. Research has shown that grasping post-disaster social psychology is essential in emergency response and rescue operations [75]. Therefore, the public's emotions displayed through social media platforms can be used to implement or adjust emergency strategies in a targeted manner.

Previous studies have shown that using emotional elements in disaster emergency response can trigger social-level psychological resonance, establish interpersonal connections, and better mobilize broader public attention or participation in disaster emergencies [76,77]. This study also indicated that emotional expressions within the topic often intertwine with social mobilization. Optimistic emotional expressions can support social mobilization and achieve better mobilization effects. It is particularly evident in organizational entities that, when implementing social mobilization, they utilize emotional elements to evoke emotional resonance among the public, thus achieving the desired effects of social mobilization. For example: "*Please pay more attention to the areas where the floodwater is being discharged. We are all farmers, and we can truly understand the feeling of seeing our hard work washed away. Zhengzhou is the capital city and cannot fall, but we must also not neglect the places where older adults gather. They are feeling helpless, and we can only feel sorrowful for them! We greatly appreciate everyone's help!*"

5.3. Social media: an essential pathway for public participation in post-disaster emergency response

Based on empirical research findings, under *#HenanFloodsRelief*, the citizens have formed a spontaneous and immediate mutual assistance space on Weibo by offering assistance, connecting resources, providing information, and disseminating scientific knowledge. It provides a vital information basis for successfully implementing traditional offline rescue efforts. This phenomenon reflects that social media has become an essential platform for promoting citizen participation in disaster emergency response and rescue to some extent.

Firstly, the openness of social media, the large user base, and the ability to transcend geographical boundaries encourage more members of the citizens to engage in disaster emergency response and rescue actively, highlighting the role of the citizens in disaster emergencies [78]. In contrast to the traditional reliance on government and professional organizations for emergency response and rescue activities, the citizens actively participate in disaster emergency response and rescue through social media, forming spontaneous online rescue activities that complement offline rescue efforts.

Secondly, the directness and real-time updating nature of information dissemination on social media enable more timely and effective information exchange during disaster response, facilitating information-based rescue efforts [53]. Affected communities can promptly share updates on the disaster situation, seek assistance, and communicate rescue needs on social media, filling the information gap that may exist in traditional rescue scenarios. Nonaffected individuals and assisting members of the citizen can provide targeted assistance and connect relevant resources based on the needs of the affected communities, enhancing the effectiveness and specificity of the aid.

Thirdly, based on the online emergency response during the Henan rainstorm, social media establishes social bonds through emotional expressions and social mobilization. This finding contradicts the stereotypical belief that social media quickly leads to public alienation and hatred, demonstrating the positive role of social media in inspiring the spirit of care among the public in disaster contexts [79–81]. At the same time, social media empowers the public to express their opinions in the public sphere and facilitates unprecedented dissemination, making the infectiousness of emotional expressions and the effectiveness of emotional mobilization more pronounced in disaster response [82]. Consequently, it has positive implications for emergency response activities in the physical world.

In previous studies, individuals removed from the event on social media tended to share dramatic content portraying suffering and destruction, reflecting a global gaze rather than a local one [83]. However, in this study, participants in the online response are more focused on the event itself. They share updated information, scientific tips, emotional expressions, and even express intentions to participate in the rescue process, demonstrating a distinct focus on local emergencies rather than a global gaze. This discovery further highlights the positive impact of social media on emergency response.

5.4. Difference: comparation between citizen participation and organization participation

Citizens and organizations exhibit different characteristics in this online rescue in the context of *#HenanFloodRelief*. In other words, citizens and organizational groups leverage their characteristics and strengths to participate in online emergency response. Citizens use their flexibility, vigorous spontaneity, and the ability to obtain firsthand information to undertake various practical on-

line rescue actions. On the other hand, with their professionalism and high influence, organizations take on a more vital role in mobilization and emotional consolation.

5.4.1. Spontaneity vs professionalism

Based on empirical research, organizations exhibit more professionalism in this online disaster response, while citizens demonstrate greater spontaneity.

Citizens promptly provide plenty of information in the context of *#HenanFloodRelief*, exhibiting spontaneous and voluntary nature. Specifically, their engagement with disaster response content and methods is closely related to their individual experiences. Previous studies have found similar results [84]. Under the topic *#HenanFloodRelief*, they tend to seek help for themselves or closely related affected groups. Simultaneously, those who post resource offerings and coordination contents are often the provisors themselves or those related to them. As a result, citizens can help to compensate for material limitations [85], but this spontaneous process makes false and outdated information significant noise, even resulting in panic [86]. To handle this problem, the citizens create norms to reduce noise and guarantee a "self-organized" system [84], demonstrated by the information verification function almost entirely shouldered by citizens.

Organizations also play a crucial role in this online emergency response but display a more professional color. The organizations consistently provided updates on the flood control information, becoming a vital component of emergency response. As an integral part of organizations, local media also fulfilled their informational role by timely reporting on disaster scenes and rescue operations. By creating evoking content, they utilize their influential communication capacity to harness the power of emotions for social mobilization. These functions highlight their characteristic of professionalism, echoing previous research [87].

In this study, citizens and organizations both contribute to social mobilization, but in quite different ways. Organizations use diverse media formats, emotionally charged content, and detailed descriptions to elicit emotions and encourage more people to join the rescue efforts ("emotional mobilization"). In contrast, citizens' posts are straightforward, directly stating their needs, requesting shares, and expressing individuality and autonomy. It highlights the contrast between professionalism and spontaneity.

5.4.2. Firsthand information vs megaphone

In online emergency response, citizen participants are primarily involved in emergencies or those related, quickly accessing firsthand information. Therefore, they predominantly express specific and individualized content, which can serve as firsthand information sources for organizational entities, reflecting the actual situation of the disaster and rescue efforts.

Organizational groups are physically distant from disaster scenes but have a notable audience base and influence. They tend to share information already posted by individuals through "reposting primarily." For example, the post: "*Help to share! Fuwai Huazhong Hospital urgently needs rescue boats, speedboats, and other water transportation tools. If available, please contact 185******** promptly. Additionally, about 50 people have been trapped in the catheterization room on the 3rd floor of the hospital for two days. Please rescue them as soon as possible!*" reflected organizations' aim to amplify the voice of citizen subjects, demonstrating the function as a "megaphone."

Hence, both semantic networks are correlated, and the citizen network positively influences the organizational network in our QAP and MR-QAP analyses. This finding validates the influence of citizens on authoritative organizations, aligning with the two-way information exchange process in risk communication [83].

5.4.3. Actual participation vs emotion mobilization

Our content analysis found that citizens predominantly take on an active role in practical rescue efforts, while organizations are inclined to provide emotional support and consolation.

In online emergency response, citizens are affected individuals or volunteers exposed to firsthand information. Based on that, citizens utilize their information resources to participate in online rescue actions such as resource mobilization, resource provision and coordination, and information verification. Empathy is an essential psychological motivation for spontaneous rescuing participation [88]. On social media, people are more likely to perceive the distressing emotions of emergency events, which evoke sympathy and a sense of empathy from them [89]. Therefore, under the topic *#HenanFloodRelief*, citizens are more prone to actively engage in actual rescue efforts rather than being mere spectators. For example, a post from a user: "I'm *in Hebei with my sisters. We're currently unemployed and want to go to Henan as volunteers to contribute. However, we can't find a channel to register as volunteers. Can anyone provide information?*" expressed a firm intention to engage in relief.

Different from citizens, organizations tend to provide emotional consolation and mobilization. Firstly, organizations are typically distant from the incident scene, making it harder to collect firsthand information. Therefore, they face more significant challenges in providing timely onsite disaster information than citizens. Secondly, organizations have a complex information publishing and review process. Information related to requests for help, resource provision, and coordination has to go through internal checks within the organization. Consequently, these online platforms post fewer posts about actual rescue efforts. Thirdly, organizations are professional and influential. Therefore, they are more inclined to use their expertise to offer emotional comfort to the audience concerned with the event. For example, the post: "*In the wind and rain, there are always people guarding you. When it's dangerous and tough, going through it hand in hand makes it less difficult! Henan, we'll get through it together!*" encourages people to come together, offering emotional consolation. At the same time, these contents evoke emotions such as sadness, sympathy, and touch, encouraging people to participate in this emergency response. This process played a role in "emotional mobilization."

6. Conclusions

In a mediatized society, social media has provided an important channel for public participation in disaster emergencies. This study takes the topic of *#HenanFloodsRelief* on Sina Weibo during the Henan floods 2021 as an example. All the texts under this topic were collected using data mining techniques, and a combination of social network analysis, content analysis, and text analysis was conducted. This research explores the characteristics of public participation in disaster emergencies and the functions it serves under this topic. The study provides a Chinese sample for examining public participation in disaster emergencies and offers insights into the topic. The key findings of this study are summarized, and several recommendations for how emergency responders can use social media are offered as follows:

In the Henan floods, social media platforms, with Sina Weibo as a representative example, have become virtual platforms for citizen participation in disaster emergencies and rescue. The openness and timeliness of social media enable the public to engage in disaster emergency activities based on information exchange and sharing, making them a significant force in this area. The *#HenanFloodsRelief* provides a convenient channel for the affected population to seek help while also serving as an information platform for citizens and organizations willing to participate in disaster rescue and provide emergency supplies. It creates an online emergency response and rescue space to support real-world disaster emergency activities. Emergency management departments need to enhance their social media strategies to build upon this dynamic. By solidifying their online presence and establishing rapid communication protocols on platforms like Sina Weibo, authorities can better manage the flow of information and support during crises. It could include creating official accounts for disaster response and using social media analytics to monitor and address the population's needs.

Besides the value of information resources, social media platforms have become spaces for the public to express emotions and virtual channels for understanding post-disaster social psychology. On the one hand, this provides an emotional basis for social mobilization in post-disaster emergencies. On the other hand, it offers a basis for governments and relevant professional organizations to adopt targeted emergency strategies. Considering this emotional dimension, governments and organizations should integrate social media monitoring into their emergency management frameworks to better understand and respond to the psychological impacts of disasters. By analyzing sentiment trends and providing emotional support through these channels, a more holistic approach to disaster response can be achieved, addressing those affected's physical and emotional needs.

Citizens and organizations' online participation exhibits different characteristics. Through social media platforms, citizen participation is spontaneous, and people post firsthand information, participating in rescue efforts. In terms of organizations, their participation shows professionalism and spreads information from citizens, functioning as megaphones. Due to their expertise, they are more inclined to play a role in emotional consolation and mobilization. However, given the massive and diverse nature of online information, there are risks associated with the public's use of information resources for disaster emergency activities. Although the citizens in the studied *#HenanFloodsRelief* topic have recognized the importance of verifying information, further research and exploration are needed to develop efficient and accurate information verification methods. Additionally, the study examines organizations' role in online rescue operations, particularly in verifying information. In response to this observation, a dual approach is needed. There is a pressing demand for the development of robust information verification mechanisms to ensure the reliability of the spontaneous content generated by citizens. Emergency management entities should collaborate with professional organizations to implement systems that can rapidly authenticate information. Furthermore, these organizations should be encouraged to guide online rescue efforts actively, ensuring that the information being circulated is accurate and constructive in mobilizing resources and support.

7. Implications and limitations

This study enriches the discourse on disaster communication by illuminating the pivotal roles that citizens and organizations play in emergency responses in China, a context less explored in existing literature. It provides insight into the dynamics of social media in emergencies, emphasizing the critical nature of emotion and information dissemination. By delving into the online interactions of 'citizens' and 'organizations,' this research offers a nuanced understanding of their contributions to relief efforts, marking a departure from generic descriptions of social media functions in disasters. The focus on a locally-oriented, disaster-relief-centric analysis of social media content contributes to a deeper appreciation of the positive influence of digital platforms in managing disasters, challenging the 'global gaze' perspective. This study, therefore, has significant implications for developing strategies that leverage social media for effective disaster communication and management, advocating for a more integrated approach involving various stakeholders in the Chinese context.

This study focuses on Sina Weibo to assess social media's impact during the Henan flood incident, recognizing its limitation due to the exclusive examination of one platform. Future research aims to expand the investigation to various social media platforms to better generalize findings. Another limitation is the lack of temporal analysis in our study, missing out on insights into the timing and frequency of social media engagements. Future efforts will include temporal analysis to understand better social media dynamics during disasters. Additionally, while our manual coding approach was thorough, it may not capture all nuances in the posts. Advancements in machine learning and natural language processing will be sought to improve coding accuracy and depth in future studies.

Funding

Table 1

Coding book

Coding Categories	Content	Example Posts
Resource Needs	information expressing various needs such as requests for assistance, requests for help, searching for missing persons, searching for lost items, and so on.	Please repost!! Please seek government attention!!! Several communities near Zhongmu Baisha Yongsheng Homes are completely flooded. The rain is still pouring, and Baisha is submerged.
Resource Provision	information related to providing resources and expressing willingness to offer assistance, such as contact information for providing supplies, information aggregation and presentation, and self-recommendation as a volunteer.	If you need assistance, please provide me with the address of the location, the number of people trapped, and the situation, and I will help you contact the rescue team.
Social Mobilization	information dissemination and mobilizing the public to participate in rescue efforts, such as spreading information and calling for public participation.	#Emergency in Xun County Town##Urgent need for rescue supplies in Xun County# Urgent notice: Attention, residents of Xun County Town!! There has been a large-scale pipe burst at Fu Zhuang Embankment, and a large quantity of sandbags is urgently needed. Please take immediate action and gather at the north side of the road, 100 m west of Vienna Hotel, to participate in filling sandbags and protect our common homeland!
Emotional expressions	expressing gratitude, sorrow, blessings, and other personal emotional expressions that do not involve actual participation in rescue efforts.	Henan, stay strong! Wishing for safety!
Rescue Actions	describing completed rescue actions, depicting the rescue scene, and providing relevant information related to the rescue efforts themselves.	In Zhongmu County, Zhengzhou, Henan, a shovel loader is carrying pregnant women, children, the elderly, and pets … Despite the ruthless flood, there is love among humanity. This image shows hopeful faces, and the people are the backbone of the rescue teams. They are the nameless heroes who shoulder the progress. #HenanWillPrevail#
Scientific Popularization	Scientific knowledge, health knowledge, self-help knowledge, and other content related to scientific popularization.	[#HowToProtectYourselfDuringHeavyRainfall#: Be Alert to "Stagnant Water" Contamination and Take Measures for Mosquito Control and Cleanliness] # SelfRescueDuringFloods#: Floods can increase the spread of diseases, and the most common risks associated with floods are contamination of drinking water facilities and stagnant water. Stagnant water can become breeding grounds for mosquitoes, posing chemical hazards and causing harm. How can we protect ourselves during floods? Watch the video.
Information Verification	information aimed at debunking false information, standardizing the format of information under the topic, eliminating noise and redundancy, and improving the efficiency of information rescue.	We appeal for not reposting rescue information repeatedly as there are already numerous channels available online for seeking help. It is important not to blindly repost rescue information as it can affect the progress of rescue operations. For those who have received assistance, please delete the rescue information promptly.

Table 2

Coding keywords

Category	Coding keywords
Resource Coordination and Provision	Give, provide, here are, need, free, provisions, supplies, summarize, online volunteers, help, seek, assistance, find, missing
Resource Mobilization	emergency, help, supplies, trapped, elderly, children, aid, need, expand, spread, urgently needed, urgent, assistance, support, request, alleviate, relief, seek, water level, trapped, status, save, emergency, shortage, there is no, request, lost, missing, find, search, contact and not, can't
Information Verification	verify, delete, duplicate, efficiency
Social Mobilization	expand, spread, please, everyone, everybody, if, lend a hand, together, contribute
Emotional Expressions	grateful, tearful, touched, love, thankful, hope, wish, bless, peace, cheer, must be OK, hold on.
Scientific Popularization	scientific, knowledge, tips, how to
Rescue Actions	Firefighter, rescue, rush, scene, flood rescue, water level, government

Table 3

High-frequency keywords

Organizational top 100 keywords	Frequency	Normalized Frequency	Citizens' top 100 keywords	Frequency	Normalized Frequency
Henan	494	1.000	Contact	2274	1.000
Heavy Rain	346	0.675	Xinxiang	1901	0.824
Zhengzhou	319	0.616	Rescue	1698	0.728
Rescue	292	0.557	Henan	1579	0.672
Firefighting	201	0.357	Heavy Rain	1577	0.671
Flood Control	190	0.333	Urgent Need	1202	0.494
Supplies	147	0.239	Seeking Help	1112	0.451
Relief	146	0.237	Supplies	1046	0.420
Xinxiang	133	0.208	Zhengzhou	1021	0.408
News	122	0.184	Xinxiang City	937	0.368

Table 3 (*continued*)

Organizational top 100 keywords	Frequency	Normalized Frequency	Citizens' top 100 keywords	Frequency	Normalized Frequency
Personnel	119	0.178	Spread	894	0.348
Seriousness	117	0.173	Friends	799	0.303
Safety	111	0.160	Weihui	725	0.268
Henan Province	108	0.154	Personnel	723	0.267
Zhengzhou	107	0.151	Signal	668	0.241
Force	105	0.147	Elderly	634	0.225
Hour	100	0.136	Nearby	613	0.215
Scene	99	0.134	Phone	599	0.209
disaster	99	0.134	Henan Province	599	0.209
help	98	0.132	Help	579	0.199
people	97	0.129	Mayday	567	0.194
Rainfall	93	0.121	Water level	546	0.184
China	93	0.121	Request	513	0.168
Emergency Response	92	0.118	Neighborhood	500	0.162
Recovery	88	0.110	Seriousness	482	0.154
Aggregation	86	0.105	Help	454	0.140
Contacts	81	0.094	Location	428	0.128
Impact	81	0.094	Makino	414	0.121
Firefighters	80	0.092	Outage	408	0.119
Transfer	75	0.081	All	405	0.117
Urgent	70	0.070	Time	403	0.116
Duration	69	0.068	Zhengzhou	374	0.103
Time	69	0.068	Government	371	0.101
Private Vehicle	68	0.066	Fengquan District	364	0.098
Refueling	68	0.066	Appeal	363	0.097
Afternoon	65	0.059	Flood Relief	350	0.091
Help	64	0.057	water stoppage	349	0.091
Vehicle	63	0.055	Verification	341	0.087
Action	62	0.053	Avenue	329	0.081
Flood Fighting	62	0.053	Hours	328	0.081
Organizations	62	0.053	Disasters	325	0.079
Disasters	61	0.050	Food	323	0.078
Donate	61	0.050	Weihui City	312	0.073
Help	60	0.048	Contacts	305	0.070
Love	60	0.048	Dike Breach	302	0.068
Carry out	59	0.046	Hardest-hit areas	301	0.068
Xinxiang	58	0.044	Power outage	298	0.067
Hospital	56	0.039	Hebi	294	0.065
Guarantee	56	0.039	Children	293	0.064
Service	55	0.037	Households	291	0.063
Center	55	0.037	Huixian	285	0.060
Beijing	55	0.037	Wei River	271	0.054
Transportation	55	0.037	Backed up	266	0.051
Neighborhood	55	0.037	Kayak	265	0.051
Citizen	55	0.037	Village	264	0.051
Weather	54	0.035	Detailed	254	0.046
Volunteer	54	0.035	Hospital	242	0.040
Passageway	54	0.035	Place	239	0.039
Heavy rain	53	0.033	Water depth	238	0.038
Waterlogged	53	0.033	Free	238	0.038
Disaster Area	52	0.031	Disaster Situation	229	0.034
As of	51	0.029	Emergency	216	0.028
Recently	51	0.029	Chunk	209	0.025
Weihui	50	0.026	New area	202	0.021
Elephant	50	0.026	Flood relief	201	0.021
Commanders	50	0.026	Thanks	199	0.020
Extraordinarily large	49	0.024	Huixian City	197	0.019
flood	47	0.020	Aid	196	0.018
Nationwide	47	0.020	Food	195	0.018
Going	47	0.020	Team	194	0.017
Received	46	0.018	Home	194	0.017
Shandong	46	0.018	Support	189	0.015
Timely	46	0.018	Attention	189	0.015
Residents	44	0.013	Intersection	188	0.015
Thank you	44	0.013	Located at	188	0.015
Neighborhood	44	0.013	Safe	187	0.014

Table 3 (*continued*)

Organizational top 100 keywords	Frequency	Normalized Frequency	Citizens' top 100 keywords	Frequency	Normalized Frequency
Drainage	43	0.011	Everywhere	186	0.014
Local	43	0.011	Charge	186	0.014
Area	43	0.011	Unstable	183	0.012
Sector	43	0.011	Whole	180	0.011
Social	43	0.011	Zhengdong	179	0.010
All	42	0.009	Emergency	178	0.010
Disasters	42	0.009	Love	178	0.010
Flood	42	0.009	Kids	177	0.009
Area	42	0.009	Rescue	175	0.009
Peace and Security	41	0.007	Downtown	173	0.008
Mission	41	0.007	Transfer	172	0.007
Ensure	41	0.007	Jalu River	172	0.007
Encounter	41	0.007	Hopscotch	169	0.006
Normal	41	0.007	Strength	167	0.005
Page	40	0.004	Donation	167	0.005
Fully	40	0.004	Evacuate	167	0.005
Good job	40	0.004	Report	165	0.004
Reinforcement	39	0.002	Ready	163	0.003
Luoyang	39	0.002	Flood Control	163	0.003
Elderly	39	0.002	Safe and sound	163	0.003
Team	39	0.002	People	162	0.002
Emergency Rescue	39	0.002	Needs	162	0.002
Road	38	0.000	Waiting	159	0.001
Life	38	0.000	Cars	157	0.000

*We rescaled word frequency by using Min-Max Normalization method: $x_{new} = (x - x_{min})/(x_{max} - x_{min})$, referring to M. J. Islam, S. Ahmad, F. Haque, M. B. I. Reaz, M. A. S. Bhuiyan and M. R. Islam, "Application of Min-Max Normalization on Subject-Invariant EMG Pattern Recognition," in IEEE Transactions on Instrumentation and Measurement, vol. 71, pp. 1–12, 2022, Art no. 2521612, doi: 10.1109/TIM.2022.3220286.

CRediT authorship contribution statement

Yubin Li: Methodology, Writing – original draft. **Li Peng:** Formal analysis, Writing – original draft. **Yun Sang:** Project administration, Funding acquisition. **Hao Gao:** Conceptualization, Formal analysis, Funding acquisition, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing.

Declaration of competing interest

We declare that there are no potential conflicts of interest in this research.

Data availability

Data will be made available on request.

References

[1] J. Twigg, I. Mosel, Emergent groups and spontaneous volunteers in urban disaster response, Environ. Urbanization 29 (2) (2017) 443–458.
[2] N. Kapucu, V. Garayev, Structure and network performance: Horizontal and vertical networks in emergency management, Adm. Soc. 48 (8) (2016) 931–961.
[3] S. McCormick, After the cap: risk assessment, citizen science and disaster recovery, Ecol. Soc. 17 (4) (2012).
[4] K. Albris, The switchboard mechanism: how social media connected citizens during the 2013 floods in Dresden, J. Contingencies Crisis Manag. 26 (3) (2018) 350–357.
[5] J. Cole, M. Walters, M. Lynch, Part of the solution, not the problem: the crowd's role in emergency response, Contemporary Social Science 6 (3) (2011) 361–375.
[6] W.-N. Wu, S.-M. Chang, B.K. Collins, Mobilizing voluntary organizations in Taiwanese emergency response: citizen engagement and local fire branch heads, Journal of Contemporary Eastern Asia 14 (2) (2015).
[7] P. Díaz, I. Aedo, M. Romano, T. Onorati, Supporting citizens 2.0 in disasters response, in: Proceedings of Conference on Methodologies, Technologies and Tools Enabling E-Government MeTTeG, 2013, pp. 1–10.
[8] W.R. Smith, K.K. Stephens, B.R. Robertson, J. Li, D. Murthy, Social media in citizen-led disaster response: rescuer roles, coordination challenges, and untapped potential, in: Proceedings of the... International ISCRAM Conference, 2018.
[9] CNNIC. "The 51st Statistical Report on China's Internet Development," Accessed: November. 8, 2023. [Online]. Available: https://www.cnnic.cn/n4/2023/0303/c88-10757.html [in Chinese].
[10] China.com.cn. "Investigation report on Zhengzhou's extraordinarily heavy rainstorm disaster released: there was a delay in reporting the problem of concealment," [Online]. Available: https://news.china.com/domestic/945/20220121/41013280.html (Accessed 8 November 2023) [in Chinese]).
[11] State Council Disaster Investigation Team. "Investigation report on the "7-20" Extremely Heavy Rainstorm Disaster in Zhengzhou, Henan Province," Accessed: November. 8, 2023. [Online]. Available: https://www.mem.gov.cn/gk/sgcc/tbzdsgdcbg/202201/P020220121639049697767.pdf [in Chinese].
[12] L.H. Cheng, H. Tang, T.G. Zhou, M. Zhang, L. Zhang, Evaluation method of natural disaster intensity and its application: a research based on comprehensive disaster condition index, J. Nat. Disasters 20 (1) (2011) 46–50.
[13] T. Aoki, K. Ito, What is the role of universities in disaster response, recovery, and rehabilitation? Focusing on our disaster victim identification project, IEEE Commun. Mag. 52 (3) (Mar. 2014) 30–37, https://doi.org/10.1109/MCOM.2014.6766081.
[14] H.-S. Noh, H.-J. Kim, S.-Y. Kang, K.-H. Park, Disaster response content for effective evacuation of disaster vulnerable classes in case of disaster, 디지털콘텐츠학회논문지 19 (12) (2018) 2267–2273.
[15] Y.S. Song, M.J. Park, J.H. Lee, B.S. Kim, Y.H. Song, Improvement measure of integrated disaster management system considering disaster damage

characteristics: focusing on the Republic of Korea, Sustainability 12 (1) (2020) 340.
[16] P. Leysia, M.A. Kenneth, Crisis informatics—new data for extraordinary times, Science 353 (2016) 224–225.
[17] M. Jia, Y. Zhang, T. Pan, W. Wu, F. Su, Ontology modeling of marine environmental disaster chain for internet information extraction: a case study on typhoon disaster, J. Geo-Inf. Sci 22 (2020) 2289–2303.
[18] J. Jensen, S. Thompson, The incident Command system: a literature review, Disasters 40 (1) (2016) 158–182, https://doi.org/10.1111/disa.12135.
[19] K. Takahagi, T. Ishida, A. Sakuraba, K. Sugita, N. Uchida, Y. Shibat, Proposal of the disaster information transmission common infrastructure system intended to rapid sharing of information in a time of mega disaster, in: 2015 18th International Conference on Network-Based Information Systems, IEEE, 2015, pp. 505–510.
[20] Y.-F. Chan, K. Alagappan, A. Gandhi, C. Donovan, M. Tewari, S.B. Zaets, Disaster management following the Chi-Chi earthquake in Taiwan, Prehospital Disaster Med. 21 (3) (2006) 196–202.
[21] P. Leysia, A. Jennings, B. Melissa, C. Carlos, C. John, et al., Crisis Informatics: Human-Centered Research on Tech & Crises: A Guided Bibliography Developed by Crisis Informatics Researchers, 2020 hal-02781763.
[22] S. Han, H. Huang, Z. Luo, C. Foropon, Harnessing the power of crowdsourcing and Internet of things in disaster response, Ann. Oper. Res. 283 (2019) 1175–1190.
[23] Y. Tim, S.L. Pan, P. Ractham, L. Kaewkitipong, Digitally enabled disaster response: the emergence of social media as boundary objects in a flooding disaster, Inf. Syst. J. 27 (2) (2017) 197–232.
[24] S. Baniya, Networked communities, technologies, and coalitional actions during global disasters, Tech. Commun. Q. 31 (4) (2022) 326–342.
[25] D.E. Wenger, R.R. Dynes, E.L. Quarantelli, Disaster Analysis: Emergency Management Offices and Arrangements, 1986.
[26] K.J. Wu, J.D. Wu, Y. Li, Mining typhoon victim information based on multi-source data fusion using social media data in China: a case study of the 2019 Super Typhoon Lekima, Natural Hazards and Risk 13 (1) (2022) 1087–1105.
[27] A.L. Hughes, A.H. Tapia, Social media in crisis: when professional responders meet digital volunteers, J. Homel. Secur. Emerg. Manag. 12 (3) (2015) 679–706.
[28] V.K. Neppalli, C. Caragea, A. Squicciarini, A. Tapia, S. Stehle, Sentiment analysis during Hurricane Sandy in emergency response, Int. J. Disaster Risk Reduc. 21 (2017) 213–222.
[29] B. Wang, J. Zhuang, Rumor response, debunking response, and decision makings of misinformed Twitter users during disasters, Nat. Hazards 93 (2018) 1145–1162.
[30] Y. Kryvasheyeu, et al., Rapid assessment of disaster damage using social media activity, Sci. Adv. 2 (3) (2016) e1500779.
[31] C. Liu, Q. Shi, Inter-organizational partnering strategies in disaster response: a complex network perspective, Systems 11 (8) (2023) 420.
[32] C. Noboa-Ramos, Y. Almodóvar-Díaz, E. Fernández-Repollet, K. Joshipura, Healthcare and social organizations' disaster preparedness, response, and recovery experience: lessons learned from hurricanes Irma and Maria, Disaster Med. Public Health Prep. 17 (2023) e306.
[33] X. Tu, Understanding the role of self-organizations in disaster relief during COVID-19: a case study from the perspective of co-production, Int. J. Disaster Risk Reduc. 74 (2022).
[34] S. Paul, S. Sosale, Witnessing a disaster: public use of digital technologies in the 2015 South Indian floods, Digital Journalism 8 (1) (2020) 15–31.
[35] C.H. Park, E.W. Johnston, Intentionally building relationships between participatory online groups and formal organizations for effective emergency response, Disasters 43 (3) (2019) 634–657.
[36] B.R. Lindsay, Social Media and Disasters: Current Uses, Future Options, and Policy Considerations, Congressional Research Service, Washington, DC, 2011.
[37] Y. Tim, S.L. Pan, P. Ractham, L. Kaewkitipong, Digitally enabled disaster response: the emergence of social media as boundary objects in a flooding disaster, Inf. Syst. J. 27 (2) (2017) 197–232.
[38] R. Solnit, A Paradise Built in Hell: the Extraordinary Communities that Arise in Disaster, Penguin, 2010.
[39] W.R. Voorhees, New Yorkers respond to the World Trade Center attack: an anatomy of an emergent volunteer organization, J. Contingencies Crisis Manag. 16 (1) (2008) 3–13.
[40] S. Arora, Post-disaster communities on social media: citizen participation in crisis communication after the Nepal earthquake, 2015, J. Appl. Commun. Res. 50 (1) (2022) 1–18.
[41] D. Murthy, Twitter: Social Communication in the Twitter Age, second ed., Polity/John Wiley & Sons, 2018.
[42] K.K. Stephens, B.W. Robertson, D. Murthy, Throw me a lifeline: articulating mobile social network dispersion and the social construction of risk in rescue communication, Mobile Media & Communication 8 (2) (2020) 149–169.
[43] C. Paciarotti, A. Cesaroni, M. Bevilacqua, The management of spontaneous volunteers: a successful model from a flood emergency in Italy, Int. J. Disaster Risk Reduc. 31 (2018) 260–274.
[44] K. Starbird, L. Palen, Voluntweeters' self-organizing by digital volunteers in times of crisis, in: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, 2011, pp. 1071–1080.
[45] C.H. Park, E.W. Johnston, "An Event-Driven Lens for Bridging Formal Organizations and Informal Online Participation: How Policy Informatics Enables Just-In-Time Responses to Crises," Policy Analytics, Modeling, and Informatics: Innovative Tools for Solving Complex Social Problems, 2018, pp. 343–361.
[46] C.H. Park, E.W. Johnston, A framework for analyzing digital volunteer contributions in emergent crisis response efforts, New Media Soc. 19 (8) (2017).
[47] L. Palen, A.L. Hughes, Social media in disaster communication, in: H. Rodríguez, W. Donner, J. Trainor (Eds.), Handbook of Disaster Research. Handbooks of Sociology and Social Research, Springer, Cham, 2018.
[48] K. Starbird, Returning to my inner nerd: following the" social" disruption of computing, Computer 46 (3) (2012) 63–65.
[49] M.T. Riccardi, The power of crowdsourcing in disaster response operations, Int. J. Disaster Risk Reduc. 20 (2016) 123–128.
[50] P. Meier, New information technologies and their impact on the humanitarian sector, Int. Rev. Red Cross 93 (884) (2011) 1239–1263.
[51] Reuter, et al., Social media in crisis management: an evaluation and analysis of crisis informatics research, Int. J. Hum. Comput. Interact. 34 (4) (2018).
[52] A. Majchrzak, S.L. Jarvenpaa, A.B. Hollingshead, Coordinating expertise among emergent groups responding to disasters, Organ. Sci. 18 (1) (2007) 147–161.
[53] Z.S. Dong, L. Meng, L. Christenson, L. Fulton, Social media information sharing for natural disaster response, Nat. Hazards 107 (2021) 2077–2104.
[54] J. He, M. Ma, Y.X. Zhou, M.K. Wang, What we have learned about the characteristics and differences of disaster information behavior in social media-A case study of the 7.20 henan heavy rain flood disaster, Sustainability 15 (6) (2023).
[55] J. Milliken, D. Linton, Prioritisation of citizen-centric information for disaster response, Disasters 40 (3) (2016) 476–493.
[56] R.R. Dynes, B.E. Aguirre, Organizational adaptation to crises: mechanisms of coordination and structural change, Crisis management 3 (1) (1979) 320.
[57] H. Ruohonen, K. Backholm, Matter of trust: how to include digital volunteers in crisis management, J. Contingencies Crisis Manag. 31 (4) (2023) 843–852.
[58] S.J.B. Kirkpatrick, Pedaling disaster: citizen bicyclists in disaster response—innovative solution or unnecessary effort? Nat. Hazards 90 (2018) 3pp.65–389.
[59] K.K. Stephens, B.W. Robertson, D. Murthy, Throw me a lifeline: articulating mobile social network dispersion and the social construction of risk in rescue communication, Mobile Media & Communication 8 (2) (2020) 149–169.
[60] S. Appleby-Arnold, N. Brockdorff, L. Fallou, R. Bossu, Truth, trust, and civic duty: cultural factors in citizens' perceptions of mobile phone apps and social media in disasters, J. Contingencies Crisis Manag. 27 (4) (2019) 293–305.
[61] R. Chari, E.L.P. Sayers, S. Amiri, M. Leinhos, V. Kotzias, J. Madrigano, E.V. Thomas, E.G. Carbone, L. Uscher-Pines, Enhancing community preparedness: an inventory and analysis of disaster citizen science activities, BMC Publ. Health 19 (1) (2019).
[62] J.T. Lu, H.Q. Bai, From QR code rally to communication action: a study on the media practice of online volunteers, Young Journalists (14) (2022) 59–61 [in Chinese].
[63] B.J. Zhang, Mediated Social Perspectives on the Rescue of Heavy Rainfall in Henan, 02, Young Journalists, 2022, pp. 110–112 [in Chinese].
[64] Y. Zhao, X.X. Chen, J.B. Jin, R.X. Zhang, Changes in the media image of traditional Chinese medicine in the context of epidemic resistance, J. Xi'an Jiaot. Univ. 40 (4) (2020) 61–70 [in Chinese].
[65] L.K. Comfort, K. Ko, A. Zagorecki, Coordination in rapidly evolving disaster response systems: the role of information, in: Agent-Based Simulation: from Modeling Methodologies to Real-World Applications: Post-Proceedings of the Third International Workshop on Agent-Based Approaches in Economic and Social Complex Systems 2004, Springer, 2005, pp. 208–219.
[66] S. Celik, S. Corbacioglu, Role of information in collective action in dynamic disaster environments, Disasters 34 (1) (2010) 137–154.

[67] J. Yin, A. Lampert, M. Cameron, B. Robinson, R. Power, Using social media to enhance emergency situation awareness, IEEE Intell. Syst. 27 (6) (2012) 52–59.

[68] B. Osatuyi, Information sharing on social media sites, Comput. Hum. Behav. 29 (6) (2013) 2622–2631.

[69] F. Demiroz, E. Akbas, The impact of social media on disaster volunteerism: evidence from Hurricane harvey, J. Homel. Secur. Emerg. Manag. 19 (2) (May 2022) 205–243, https://doi.org/10.1515/jhsem-2020-0077.

[70] S. Kumar, N. Shah, False information on web and social media: a survey, arXiv preprint arXiv:1804.08559 (2018).

[71] K. Shu, A. Sliva, S. Wang, J. Tang, H. Liu, Fake news detection on social media: a data mining perspective, ACM SIGKDD explorations newsletter 19 (1) (2017) 22–36.

[72] N. Bharosa, J. Lee, M. Janssen, Challenges and obstacles in sharing and coordinating information during multi-agency disaster response: propositions from field exercises, Inf. Syst. Front 12 (2010) 49–65.

[73] M.F. Goodchild, J.A. Glennon, Crowdsourcing geographic information for disaster response: a research frontier, International Journal of Digital Earth 3 (3) (2010) 231–241.

[74] J. Li, K.K. Stephens, Y. Zhu, D. Murthy, Using social media to call for help in Hurricane Harvey: bonding emotion, culture, and community relationships, Int. J. Disaster Risk Reduc. 38 (Aug. 2019) 101212, https://doi.org/10.1016/j.ijdrr.2019.101212.

[75] T. Yang, et al., Social media big data mining and spatio-temporal analysis on public emotions for disaster mitigation, ISPRS Int. J. Geo-Inf. 8 (1) (2019) 29.

[76] A. Ibrahim, J. Ye, C. Hoffner, Diffusion of news of the shuttle Columbia disaster: the role of emotional responses and motives for interpersonal communication, Commun. Res. Rep. 25 (2) (2008) 91–101.

[77] M. Siegrist, H. Gutscher, Natural hazards and motivation for mitigation behavior: people cannot predict the affect evoked by a severe flood, Risk Anal.: Int. J. 28 (3) (2008) 771–778.

[78] S. Arora, Post-disaster communities on social media: citizen participation in crisis communication after the Nepal earthquake, 2015, J. Appl. Commun. Res. 50 (1) (2022) 1–18.

[79] S. Boulianne, J. Minaker, T.J. Haney, Does compassion go viral? Social media, caring, and the Fort McMurray wildfire, Inf. Commun. Soc. 21 (5) (2018) 697–711.

[80] C. Reuter, A.L. Hughes, M.-A. Kaufhold, Social media in crisis management: an evaluation and analysis of crisis informatics research, Int. J. Hum. Comput. Interact. 34 (4) (Apr. 2018) 280–294, https://doi.org/10.1080/10447318.2018.1427832.

[81] L. Palen, A.L. Hughes, Social media in disaster communication, in: H. Rodríguez, W. Donner, J.E. Trainor (Eds.), Handbooks of Sociology and Social Research, Springer International Publishing, Cham, 2018, pp. 497–518 https://doi.org/10.1007/978-3-319-63254-4_24, in Handbook of Disaster Research.

[82] G. Neubaum, L. Rösner, A.M. Rosenthal-von der Pütten, N.C. Krämer, Psychosocial functions of social media usage in a disaster situation: a multi-methodological approach, Comput. Hum. Behav. 34 (2014) 28–38.

[83] L. Palen, et al., Crisis Informatics: Human-Centered Research on Tech & Crises, Jun. 2020 [Online]. Available: https://hal.science/hal-02781763. (Accessed 1 February 2024).

[84] K. Starbird, L. Palen, Voluntweeters': self-organizing by digital volunteers in times of crisis, in: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, ACM, Vancouver BC Canada, May 2011, pp. 1071–1080, https://doi.org/10.1145/1978942.1979102.

[85] K.K. Stephens, B.W. Robertson, D. Murthy, Throw me a lifeline: articulating mobile social network dispersion and the social construction of risk in rescue communication, Mobile Media & Communication 8 (2) (May 2020) 149–169, https://doi.org/10.1177/2050157919846522.

[86] L. Clarke, C. Chess, Elites and panic: more to fear than fear itself, Soc. Forces 87 (2) (Dec. 2008) 993–1014, https://doi.org/10.1353/sof.0.0155.

[87] Y. Chen, J. Zhang, P.R. Tadikamalla, L. Zhou, The mechanism of social organization participation in natural hazards emergency relief: a case study based on the social network analysis, Int. J. Environ. Res. Publ. Health 16 (21) (Jan. 2019) 21, https://doi.org/10.3390/ijerph16214110.

[88] J.A. Barraza, Positive emotional expectations predict volunteer outcomes for new volunteers, Motiv. Emot. 35 (2) (Jun. 2011) 211–219, https://doi.org/10.1007/s11031-011-9210-4.

[89] G. Neubaum, L. Rösner, A.M. Rosenthal-von der Pütten, N.C. Krämer, Psychosocial functions of social media usage in a disaster situation: a multi-methodological approach, Comput. Hum. Behav. 34 (May 2014) 28–38, https://doi.org/10.1016/j.chb.2014.01.021.