

Use of Social Media Data in Disaster Management: A Case Study of Heavy Rainstorm in Zhengzhou China

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ABSTRACT

Social media has evolved itself as a significant tool used by people for information spread during emergencies like natural or man-made disasters. Real-time analysis of this huge, collected data can play a vital role in disaster Warning, response and assistance exercises. Firstly, a case study of 720 Zhengzhou heavy rainstorm was implemented for verifying the effectiveness of microblog's response to disaster from two perspectives: word frequency, topic change of public attention to disaster. Then combined with the characteristics of social media data and overseas cases, the following points are put forward: 1) Social media not only improves the efficiency of information communication, but also increases the possibility of co-operation between the government and the public, it is necessary to develop a more comprehensive online disaster management strategy to improve the timeliness of disaster management. 2) Social media plays a unique role in framing risk topics. The government should create an interactive information platform, pay attention to popular topics, and receive information from the public. To achieve two-way communication between the government and the public. 3) In the aftermath of a disaster event, it is of utmost importance to ensure efficient allocation of emergency resources to locations where the resources are needed. The government should make use of the digital application of social media in various aspects to provide decision support and program reference for the improvement and optimization of disaster management resources in the future.

Key words: Social media; disaster management; disaster resources; Heavy Rainstorm;

1. Introduction

Under the influence of climate change and human activities, numerous natural disasters strike across the globe every year. Natural disasters not only restrict the sustainable development of the economy and society, but also pose a serious threat to the life and property safety of victims. Natural disasters have complexities, uncertainties, and dynamic characteristics (Sun, *et. al.*, 2016: 1). Serious natural disasters often cause high economic losses and heavy casualties. The frequent occurrence of major natural disasters results in significant infrastructure damage and cause many problems and challenges for sustainable development. It is commonly agreeable that there is no way of neutralizing all negative impacts resulted from disasters (Moe & Pathranarakul, 2006: 397). However, efforts can be made to reduce their impacts through disaster management. Disaster management has played a significant role in mitigating and minimizing loss of life and damage to properties and infrastructure (Phengsuwan, *et. al.*, 2021: 1). In last few years information and communication technology (ICT) is

being used widely during various stages of emergency to expedite the relief activities (Şahin, *et. al.* 2019: 150). Earlier orthodox techniques like calls, messages, direct inquiry or consulting the people were being used to collect information (Bhoi, *et. al.*, 2020: 1). Effective disaster management demands intelligent infrastructure for the collection, integration, management, and analysis of a variety of distributed data sources (Phengsuwan, *et. al.*, 2021: 1).

With the high popularity of information technology and the in-depth application of the Internet, social media has become a prime means of communication in the 20th century. Social media applications such as Twitter, Facebook, YouTube, Instagram, and blogs are an important means of people's daily communication and one of the most popular information communication channels. At the same time, social media continues to undergo evolution over the years, and the adoption of social media to combat and manage crises has become a new global phenomenon. Before the twenty-first century, information about disasters was released largely via televisions, media advisories, press re-

leases, and closely monitored print and web publication media (Tang, *et. al.*, 2015: 2). In recent years, social media data are increasingly being used in disaster management for disseminating critical information to the public about the hazard event, relief, and recovery (Xiao, *et. al.*, 2015: 1664). The growth in social media promotes disaster information sharing process, individuals are better connected with the rest of the world than ever before (Li, *et. al.*, 2019: 1). This makes it possible for disaster-related information to be shared in real time, enabling people to obtain information without the slightest time gap (Tang, *et. al.*, 2015: 2). Compared with traditional media, social media has become an important channel for crisis communication during emergency conditions by providing greater capacity and higher levels of trust and interaction (Kusumasari & Prabowo, 2020: 3416).

Social media played prominent roles in many recent natural disasters, including Hurricane Harvey in 2017, Australia's bushfire, as well as COVID-19. From July 20 to 23, 2021, Zhengzhou, Henan Province in central China suffered a rare rainstorm in history. This rainstorm had a long time, wide range, large total amount, and strong extremeness. The rainfall in a single hour exceeded 200 mm, which refreshed the hourly rainfall extreme value of China's land. The daily rainfall of 20 national-level meteorological stations exceeded the historical extreme value since the establishment of the station, which is the most extensive and strongest rainstorm in Zhengzhou meteorological observation history. It is a particularly major natural disaster that caused serious urban waterlogging, river floods, landslides, and other disasters due to extreme rainstorms, resulting in heavy casualties and property losses. The severe rainstorm and flood disaster caused more than 14 million people, and 398 people died in the rainstorm. The direct economic loss is about 120 billion yuan (17.8 billion U.S. dollars), including infrastructure paralysis, collapsed buildings, car washouts, flooded facilities, and resource interruptions. In addition, the severe rainstorm has caused irreversible damage to historical heritage (such as museums, archaeological sites, Longmen Grottoes and Shaolin Temple, etc.). In the face of uncertainty during disastrous moments, a growing number of people choose social media as a solution to retrieving updated information about the disaster areas and disseminating information to support those suffering (Kaewkitipong & Ractham, 2012: 2). Governments also proper analysis of social media information may be significantly helpful to look over impacted people, assess damages, and appropriate mapping of necessary resources such as medicine, doctor, water, food, and shelter at the time of need (Schempp, *et. al.*, 2019).

This paper aims to study Weibo posts about the

2021 Zhengzhou flood disaster to demonstrate the usefulness of social media data in disaster management. Through Weibo data collection and content analysis, understanding the vulnerability of victims and the disaster resources needed during disasters can help governments, emergency management agencies, and NGOs formulate timely disaster response measures. Additionally, it can help them optimize crisis communication and information release strategies to assist victims, inform people, help victims respond effectively to disasters, and improve disaster management and resilience. Individuals struggle to make clear, logical judgments when they are wrapped up in fear and anxiety.

2. Theoretical Background

2.1. Social Media Data

Social media is a broad term for a variety of web-based platforms and services that allow users to develop public or semi-public profiles and content, and to connect with other users' profiles and content (Houston, *et. al.*, 2015: 3). Social media is a virtual community where in one can share information and thoughts and enable people to conduct online communications intended for interaction, community input, and collaboration (Tang, *et. al.*, 2015: 173). As of January 2020, over 4.26 billion people were using social media, a number projected to increase to almost six billion in 2027 as lesser developed digital markets catch up with other regions when it comes to infrastructure development and the availability of cheap mobile devices. Social media is an integral part of daily internet usage. On average, internet users spend 144 minutes per day on social media and messaging apps, an increase of more than half an hour since 2015. Due to the COVID-19 outbreak in 2020, all major social media platforms saw an increase in daily usage.

Social media applications, which have achieved considerable penetration into the everyday life of many users, provide an invaluable source of data regarding user thoughts, beliefs, and opinions (Jamali, *et. al.*, 2019: 27). Social media data are multi-dimensional and contain rich information about human activities, environmental conditions, and public sentiment. Market leader Facebook was the first social network to surpass one billion registered accounts and with roughly 2.93 billion monthly active users as of the first quarter of 2022, Facebook is the most used online social media. the number of global monetizable daily active users (mDAU) on Twitter amounted to 229 million users in 2021. A total of 500 million tweets are sent by Twitter users every day, equivalent to 5787 tweets per second. Moreover, Instagram has over 2 billion monthly active users (MAUs) as of 2021, and 500 million daily active users updated their stories. Data are

comprised of several types of information, including user ID, timestamp, text, coordinates, retweet and so forth. The large number of posts generated by these active users exemplifies the variety of dimensions of social media data. Wang & Ye (2018) divided social media data into four dimensions: space, time, content and network. (1) Spatial information in social media data is critical for disaster management. There are mainly two types of spatial information in social media data: exact coordinates (i.e. longitudes and latitudes) and toponyms (e.g. a city name) (Huang & Wong 2016: 1875). Precise coordinates can be requested if the built-in GPS in the user's device is turned on. (2) Disaster management is often time-critical and thus requires timely information collection and analysis. Every social media data comes with a high-resolution timestamp. A typical way of using this temporal information is to analyze how people's responses to disasters change over time. (3) As people's conversational content on social media varies in terms of topics and emotions, it is often required to classify social media messages into distinct categories. Situational awareness in natural disaster management could be enhanced by social media data, especially the content dimension. (4) The emergence of online networks provides great opportunities to investigate information exchange behaviors of various agents (e.g. ordinary users, authoritative agencies and news media) in disaster situations.

2.2. Social media data in disaster management

When a technology is developed as a product that fulfils a particular requirement of society. This will eventually transform a technology into a solution. Decades ago, social media was a technology for social networking, and now it is being used as a solution tool rather than a sole technology (Kankanamge, *et.al.*, 2020: 2). People used social media information to assess the disaster events, gather real-time information, and to disseminate information, many social media have become useful tools during disaster events. are now being utilized by Governments, and non-Governmental organizations to manage disasters.

Two important purposes of applying social media data to disaster emergency management are situational awareness and information sharing (Sakaki, *et. al.*, 2013: 239), which have applications in the four stages of disaster emergency management: disaster prevention, preparedness, response, and recovery and reconstruction potential (Yu, *et al.*, 2018: 165). In the disaster prevention stage, engineering measures, insurance reinsurance and disaster mitigation strategic planning have received more attention. To implement the above measures and plans, reliable disaster big data is necessary. Social media data provides information reference

for the disaster prevention stage, and a typical application is mobile phone signaling data. By collecting detailed information on cell phone calls and waiting before and after a disaster, it is possible to estimate the population distribution and socioeconomic status of the region for risk assessment. Mobile data, such as mobile phones, can help decision-makers understand crowd behavior, and then model and evaluate disaster management plans (Ghurye, *et. al.*, 2016: 20). The planning of shelters is also an important measure in the disaster prevention stage. Kusumo, *et. al.* (2017) analyzed the evacuation of residents and showed that the location of the shelters required by residents was only 35.6% consistent with the location of the government shelters. This result provides a reference for the selection of shelters.

In the disaster preparedness stage, it is necessary to implement emergency material reserves, convene disaster relief teams, and communication logistics to ensure the effectiveness of disaster response. Timely monitoring of the disaster process is a necessary measure in the disaster preparedness stage. Social media data enables monitoring of disaster situations. For example, when a typhoon comes, people respond to local wind and rain conditions by posting social media information. By accessing social media platforms, emergency management authorities can obtain basic information on disasters and establish situational awareness of disaster prevention and preparedness (Chan, 2012: 4). Studies have used social media to monitor rainfall and flood events and have applied web maps to disaster preparedness in cities such as Paris and London (Feng & Sester, 2018: 39).

In the response stage, decision makers need to have a global understanding of the disaster situation through indicator statistics. At present, the main disaster statistics in China come from the reporting of indicators, but there is a time lag in this method. Social media can support the acquisition of statistical indicators: By extracting the text and picture information related to disaster-causing factors in social media, indicators such as the distribution and intensity of disaster-causing factors can be quickly obtained. Similarly, by extracting and counting information related to the severity of the disaster, the disaster situation near social media users can be initially reflected. These indicators can be used as an information reference when integrating and reporting data. Rapid assessment of losses. For example, Weibo and Twitter can be used to estimate the degree of damage in typhoon-affected areas. FEMA also organized public and private groups to analyze disaster tweets to identify needs and provide assistance. It can be seen that social media data in disaster response is important. of importance. In addition, there are related studies demonstrating that the combination of social media

data and observational data can improve the accuracy of the former and improve the temporal resolution of the latter (Cervone, *et. al.*, 2016: 103). Comprehensive data are very valuable in planning and emergency response, meaning that the sooner this data is provided, the lower the death toll and property damage will be (Liou, *et. al.*, 2010: 3356). Detailed demand information. Social media data comes from the masses, whose needs are precise down to the individual. When conducting resource analysis and material scheduling, detailed demand planning can improve rescue efficiency.

During the recovery and reconstruction stage, the information on the recovery of various industries, the reconstruction of infrastructure, and the psychological changes of the masses is the concern of decision makers. Social media can show progress and spatiotemporal patterns of restoration and reconstruction. For example, Yan, *et. al.* (2017) used geotagged social photos to monitor and assess the recovery of tourism after the 2013 Philippine earthquake and Typhoon Haiyan through a visualization study. In addition, the machine learning method can quickly distinguish the priorities in the post-disaster reconstruction stage, which helps the government to formulate scientific and targeted rescue strategies. In addition, social media can also reflect and estimate the actual location of the victims and the topics of post-disaster discussions, helping the government and people adapt to the post-disaster environment and strengthen disaster governance (Zhou & Liu, 2019: 177).

2.3. Literature Review

Jin, *et. al.* (2021) discussed Weibo data and meteorological data to explore the effectiveness of typhoon Weibo disaster response, and uses LDA topic model, network community model and sentiment analysis to mine the topic evolution and sentiment trends of Weibo texts during typhoon disasters. And the differences in topic and emotional expression between official Weibo texts and public Weibo texts are further compared.

Han & Wang (2019) analyzed Weibo texts in terms of space, time, and content related to the 2018 Shouguang flood, which caused casualties and economic losses, arousing widespread public concern in China. The results indicated that The majority of Weibo texts about the Shouguang flood were related to “public sentiment”, among which “questioning the government and media” was the most commonly expressed. The Weibo text numbers varied over time for different topics and sentiments that corresponded to the different developmental stages of the flood. The findings can be used to help researchers, public servants, and officials to better understand public sentiments

towards disaster events, to accelerate disaster responses, and to support post-disaster management.

Yang & Stewart (2019) harvested a corpus of over 13,000 tweets using Twitter’s streaming API, across three phases of the Hurricane Harvey event: preparedness, response and recovery. Both text and social network analysis (SNA) techniques were employed including word clouds to analyze data. Findings indicate that emergency management agencies should consider adopting a three-phase strategy to not only improve communication, but also narrowcast specific types of information corresponding to relevant periods of a crisis episode.

Wu, *et. al.* (2020) summarized the potential, advantages, and problems of applying social media data in disaster emergency management. The results show that: 1) Social media data can support disaster early warning, real-time monitoring, and loss and rescue needs assessment, assist rapid emergency response. 2) The advantage of social media data is that it can ensure the timeliness and continuity of disaster information acquisition. 3) Some problems limit the accuracy of social media data analysis results, including limited geographical location information, lack of professional corpus, and complexity of information noise processing, among others.

Malawani, *et. al.* (2020) through topic modelling and content analysis, examined the priorities of the victims expressed in Twitter and how the priorities changed over a year. Findings of this study argue that housing and relief goods have been the top priorities of the victims. Victims are seeking relief goods, especially when they are in evacuation centers. Also, the lack of legal basis hinders government officials from integrating social media information into policymaking.

Courtney (2021) explored the unique role of social media in risk perception and communication of uncertainty, using the 2017 U.S. Hurricane Irma as a case study. The study found that through the dissemination of social media platforms, disaster risk issues have been gradually enlarged, among which the diversity of information sources for the construction of risk issues, the diversity of risk presentation methods, and simplified emotional mobilization have improved the public's risk perception. At the same time, the cross-space information flow and multi-level risk communication on social media platforms not only satisfy the public's information needs but also appease their fears and guide all relevant stakeholders to form a joint force to jointly build disaster prevention and mitigation plans and achieve scientific disaster risk management.

Huang, *et. al.* (2021) constructed a social media-based rainstorm disaster information mining model. The rainstorm event on April 11, 2019 is selected

as an example, 10, 015 Weibo texts about “Shenzhen rainstorm” are collected and four types of Weibo text themes are identified. The results show that the proposed mining model for rainstorm disaster information performs well on the identification of disaster information of the Weibo texts. The proposed mining approach for rainstorm disaster information may provide the basic and real-time information support for emergency rescue and relief work.

Wang, et. al. (2016) presented a new method of mining and analysis of emergency information with a case study to analyze the Weibo text streams during the 2012 'Beijing Rainstorm'. The real-time emergency information topic was built, and the emergency information from real-time text stream were identified and located. Decompose the time data to explore the trend of changes in the number of Weibo texts related to 'Heavy Rain in Beijing'. According to different topics, using statistical and spatial analysis, a possible spatial structure for distributing resources in response to emergencies was indicated. The results can help to understand how the emergency events are evolved and what are impacted by the events.

3. The Case Study

3.1. Social media in disaster management during Hurricane Harvey

Hurricane Harvey was social media's first real stress test as a disaster response and recovery mechanism. It is an ideal case study of social media's role in disaster management (Courtney, 2021: 95). In August 2017, the Category 4 storm Hurricane Harvey struck the Gulf Coast of Texas, particularly the metropolitan area of Houston. It made landfall near Rockport, Texas on August 25. During the landfall, Harvey brought strong winds and record-level rainfall to American Southwest, directly causing a large-scale flooding that paralyzed major highways and airports, and submerged thousands of residential housings (National Hurricane Center, 2018). As the hurricane intensified, the government called upon Houston residents to use boats and high-water vehicles for emergency rescue. social media is used during disasters by the public to facilitate reporting of their emergency situations, their locations, and requesting rescue and help (Yang & Stewart, 2019: 1337). Social media offered the infrastructure for a bottom-up citizen-led emergency network to emerge overnight (Courtney, 2021: 95). That platforms such as Facebook, Nextdoor, and Twitter provide a wealth of disaster information during Hurricane Harvey, The volume graph of tweets for each of "rescue," "need" and "help" peaked on the first two days. Social media has become important communication

tools for disaster-hit groups, enterprises and emergency management departments.

3.2. Social media in disaster management during Australia's bushfire

Climate change is already influencing fire seasons around the world, wildfire seasons are extending as the number of dry and hot days increases (Halofsky, et. al., 2020: 3). By March 2020 Australia's bushfire burnt almost 19 million hectares, destroyed over 3,000 houses, and killed 33 people. Data showed that they were unprecedented in terms of impact on all areas (Filkov, et. al., 2020: 44). Facebook collects fire location data through mobile devices and draws real-time disaster maps (Facebook Disaster Maps) on this basis, providing emergency managers with accurate crisis assessment, reconstruction emergency rescue and post-disaster plans and other references. Fire geo-information can be more easily shared through social media, with the help of technologies such as Volunteer Geo-Information and web maps to create real-time fire geo-information and make this information freely available to emergency managers and the public about the state of the fire. Social media is also conducive to assisting the government and the public in scientifically formulating evacuation plans and allocating disaster relief resources. Facebook also called and launched more than 19,000 fundraisers, nominated more than 250 non-profit organizations as fundraisers, and raised donations from 75 countries and regions, raising more than \$73 million (Zhou & Zhong, 2022: 124). Therefore, Facebook is becoming a valuable social media to deliver disaster information and attract attention from local communities.

3.3 Social media in disaster management during COVID-19

Due to COVID-19, various countries introduced lockdowns and limited citizen movements, these restrictions triggered an increased use of social media by the public (Yigitcanlar, et. al., 2020: 1). The COVID-19 pandemic is the first pandemic to take place in the social media age, in a very short time span, COVID-19 has fundamentally changed the way that field epidemiologists work, with remote working arrangements becoming common and meetings having been shifted online (Hammer, et. al., 2021: 11). As the pandemic continues to evolve, the government uses social media to educate the public on how to choose and wear masks, and to disseminate information on epidemic prevention and scientific epidemic prevention. At the same time, the government also disseminated virus surveillance information, medical facilities, changes in the number of confirmed cases and itineraries to the public through social media. Social media become

a strong platform for spreading public health awareness and advocacy regarding public health issues (Sahni & Sharma, 2020: 72). Most significantly, during pandemic situations, where social distancing is a must, social media analytics can help policy- and decision-makers to screen community behaviors without reaching the community directly (Yigitcanlar, et. al., 2020: 7). Social media is being used not only by governments and the public but also by those directly responding to the pandemic. Public health professionals are now using social media to survey public attitudes, manage the info emic, assess mental health, predict COVID-19 cases (Tsao, et. al., 2021: 176). Social media become an important avenue for physicians to share experiences, to collaborate on research, and to initiate discussion on a global scale. Social media also serve as a way for disaster management, outbreak prevention, and emergency response staff to easily communicate and access critical information collected by organizations like the WHO and the Center for Disease Control (Sahni & Sharma, 2020: 72).

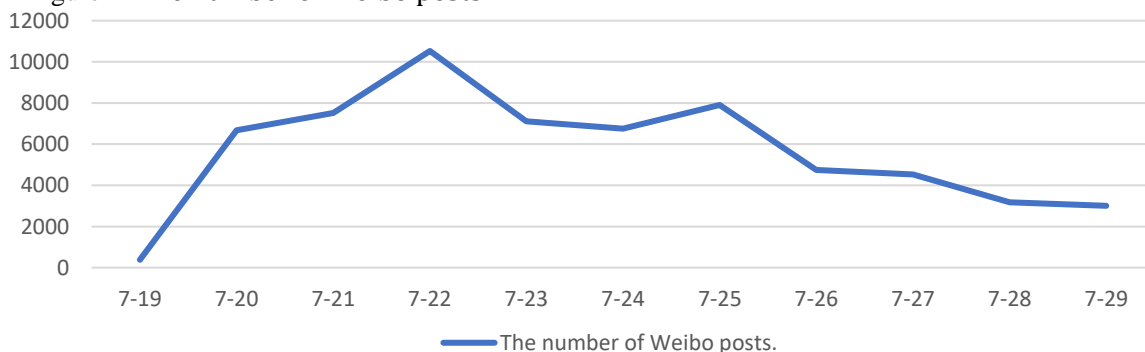
4. Research data and method

Weibo is used as the research object; it is a popular social-media platform. In particular, there are thousands of pieces of Weibo data on natural disasters every day. During natural disasters, people report disaster information through Weibo, express their urgent needs, and seek help. As a result, Weibo data have become an important source of data for disaster management. Text, images, and geographic location data can be used to learn more about natural disasters and provide a data basis for natural disaster management.

In July 2021, Zhengzhou in China's Henan Province was hit by successive heavy rains, stimulating a heated discussion on microblogging platforms. Heavy rainfall started in Zhengzhou since July 18. On July 19, the Zhengzhou Meteorological Bureau issued a red warning signal for heavy rain. On July 20, "Rainstorm in Henan" and "Water curtain cave in Zhengzhou Subway Line 4" were trending topics on microblogging platforms. The flood control emergency response level was updated to Level I

on July 21. With the reduction in rain and the effective promotion of rescue measures, the disaster situation has gradually improved, and the operation of urban public traffic has gradually returned to normal conditions. The flood control emergency response level was lowered to Level IV on July 23. On August 2, a press conference on flood control and disaster relief in Henan Province was held, in which the Chinese government announced the establishment of an investigation team for the 7·20 rainstorm disaster in Zhengzhou, Henan Province. Based on the advanced search page of Weibo, this study obtained original Weibo related themes of heavy rainstorm in Zhengzhou through the search method of "keyword + time period + location". The Henan Meteorological Bureau began to issue heavy rain warning information from 19 July 2021. The heavy rain was most concentrated on 20 July. The Chinese government called 7·20 Heavy rainstorm in Zhengzhou. Considering the date rainstorm struck, this study used data from Weibo, from 19 July to 29 July. We used the public application program interfaces provided by Weibo for data collection. We collected 62,312 original posts and their reposts containing the term #Zhengzhou, #Heavy rainstorm. Each post contained information on the user ID, posting time, post content, user location, and number of followers. As shown in Figure 1, the number of Weibo postings reached a peak from the second day to the fourth day after the rainstorm. Among them, the number of Weibo postings on 22 July was at most 10,530, accounting for 17.46% of the total number of Weibo posts. The analysis found that from the heavy rain on 20 July to 23 July, it was in the emergency rescue stage of the disaster, and the majority of netizens paid great attention to the accident. On July 25, the carriage of Zhengzhou Metro Line 5, which was trapped in the heavy rain, was towed out and transported away, the number of topics increased slightly again. With the end of the emergency rescue on 25 July, the number of posts on Weibo concerning Zhengzhou rainstorm decreased. Despite this, it can still be observed that the gathered posts were still related to the demand for disaster resources. The attention of Weibo users to the disaster has continue

Figure 1. The number of Weibo posts.



5. Results

5.1. Feature analysis of content topic

The feature analysis of content topic is an essential tool for data mining on social media and has attracted extensive attention in recent years. Empirical research has found that the release of social data is closely related to the cycle of disaster occurrence, which is usually divided into three stages: pre-disaster preparation, emergency response, and post-disaster recovery. People discuss different topics on social media at different stages. In the early days of a disaster, people discussed content mainly on disaster preparedness and weather warnings. After the disaster, people focused on disaster discussions and emergency rescue. In the later stage of the disaster, people mainly focused on post-disaster recovery and reconstruction. Thus, different themes occurred in different periods.

Wang, et.al. (2016) took the 721 heavy rainstorm in Beijing as an example, collected Weibo data for 20 days during rainstorm, and extracted 79,723 texts as samples of emergency topics. By mining the topic information, the feature words were defined as six aspects: traffic situation, weather warn-

ing, rescue information, disaster information, urban waterlogging cause, loss and impact. Han & Wang (2019) took the 2018 Shouguang City Flood in China as an example, using web crawlers and Weibo API, 28,608 original Weibo messages were collected with “Shouguang” as the keyword between August 19 and 28. the flood-related Weibo were generalized into six topics: “weather warning”, “traffic conditions”, “rescue information”, “public sentiment”, “disaster information”, and “other.” Zhang, et. al. (2022) used Weibo data during the 2021 Henan heavy storm as the research object, combines the Weibo API and web crawler to obtain a total of 28,099 pieces of data from 18 July 2021 to 30 July 2021. By mining the topic information, the original words are defined as six aspects: weather warning, traffic situation, rescue information, disaster information, disaster cause, casualty, and damage. In this study, based on the previous research, combining a Chinese content mining tool called GooSeeker, the original words are defined as six aspects: weather condition, disaster information, rescue information, disaster cause, casualties and damage, and public sentiment. Table 1 shows the topics and topic words.

Table 1. Content topic

Topic	Topic Word
1. Weather condition	rainstorm, heavy, rainfall, warning
2. Disaster information	traffic obstruction, subway Line 5, tunnel, power outage, emergency avoidance
3. Rescue information	goods and services needed by victims, rescue team, water, life jacket, hospital, shelter
4. Disaster cause	urban flooding, landslide, lack disaster awareness, lack disaster preparedness, low emergency response capability
5. Casualties and damage	life, victims, missing, property, house collapse, economic loss, the area affected by crops
6. Public sentiment	come on, hope, sad, help each other, thanksgiving, donations, the questioning the government and media, praying for the victims, worrying about prices

Figure 2 presents the temporal changes of topic during the heavy rainstorm in Zhengzhou. Before the rainstorm begins, little attention has been paid to weather warnings during heavy rains. From July 20, Zhengzhou experienced a heavy rain, and people began to publish weather warning information through Weibo, so the number of Weibo posts with a weather warning on 20 July was significantly more than that of other topics, and on 27 July the Typhoon In-fa affected Henan, so the number of microblogs regarding weather warning increased on 27 July. This heavy rainstorm was affected by the early stage of the Typhoon In-fa, so when the Typhoon In-fa landed in mainland China on July 27, the number of weather warnings increased

again. After the intensive rainstorm on the afternoon of July 20, a total of 377,000 people were relocated, many cars on a road were washed up by the rain, tunnel became flooded, the Ying River, the province's largest river, overflowed causing flooding in its surrounding areas, and an aluminum alloy factory exploded, etc. With the development of disaster, the number of Weibo posts regarding disaster information rapidly increased. On 24 July, as rainfall declined, people's concerns about disaster information gradually decreased. From 21 July, there was an explosion of social media about rescue information and casualty loss, rose sharply on July 22 and peaked on July 25. The number of Weibo texts related to public sentiment was high. It started rising on July 21, surged on July 23, and public sentiment peaked on July 25 as subway cars



(2) Word cloud of Weibo topics on July 21

July 22 to 24 was still the emergency rescue period, Rescue and assistance are the words that appear most frequently. As the heavy rain continued, many victims in Xinxiang County, Hebi County and other areas were urgently transferred. Increased frequency of the elderly, children, disaster resources, hospitals, and vulnerability. Smaller-font words included donation, please, support, price increase. Drinking water, food, life jackets, and feminine supplies, are priorities for disaster victims in disaster management resources. This suggests that emergency transfers are an effective disaster response method during persistent rainfall. At the same time, the elderly and children, as the weak in disasters, are the most vulnerable when disasters occur, and they are also the focus of social media attention.



(3) Word cloud of Weibo topics on July 22

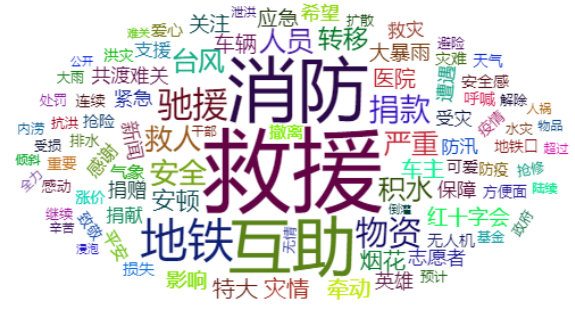


(4) Word cloud of Weibo topics on July 23



(5) Word cloud of Weibo topics on July 24

On July 25, flooded subway cars were salvaged, so subway became a frequently appeared word again. disaster resources, donations, Red Cross, help, logistics were the frequently appeared words. Specifically, disaster resources include drinking water, food, life jackets, water pumps, shelters, feminine items, flashlights, ambulances, etc. It is worth mentioning that with the development of science and technology, drones are widely used in rescue, and drones have become an indispensable resource in disasters. However, words of negative emotions such as drowning, missing, victim, collapse, danger, area affected, economic loss also started to appear. At the same time, words that questioned the government and the media began to appear, they included disclosure, punishment, fake news, concealment, etc.



(6) Word cloud of Weibo topics on July 25

6. Conclusion

In recent years, the acquisition and analysis of disaster information have become key issues for government and scientific research institutions. Social media data can enable officials and victims to be the truth and disseminators of natural disaster information, simultaneously, and social media data have the advantages of real-time and low latency. Therefore, social media has become an important source of natural disaster information, using social media for disaster response comes with the great potential (Huang, et. al., 2016: 1873). More and more people use the Internet to obtain and publish

accident rescue information, express personal opinions and share emotions, etc., thus generating massive, real-time and complete accident rescue network data on the network platform. First, this study provides a brief overview of social media data and the application of social media in disaster management. Then, this study discusses the application of social media in disaster response and disaster recovery during Hurricane Harvey in the United States, wildfires in Australia, and the epidemic in China. Finally, taking the 720 Zhengzhou rainstorm as an example, based on Weibo data, this paper discusses the changes of topics people pay attention to on social media and the resource requirements of disaster management after the disaster. As the data processing showed, social media can accurately grasp the thematic changes of netizens after the disaster, as well as the location and material needs of the victims after the disaster.

Combined with overseas cases and the data results of this paper, the following points are put forward: 1) After a disaster occurs, social organizations, volunteers and the public spontaneously record and share the disaster situation to fill the gap in emergency management information coverage, which is very useful for large-scale disaster management. Social media has proven to be a reliable emergency communication channel when traditional communication tools fail. It not only improves the efficiency of information communication, but also increases the possibility of cooperation between the government and the public, thereby reducing disaster management capital. Faced with the fact that social media around the world is affecting disaster management, governments need to develop a more comprehensive online disaster management strategy to improve the timeliness of disaster management. 2) Social media plays a unique role in framing risk topics. Through the dissemination of social media platforms, a series of risk topics caused by disasters have been gradually enlarged. At the same time, the diversity of subjects in the construction of risk topics, the diversity of risk presentation methods, and simplified emotional mobilization have improved the public's risk perception. Therefore, the government should create an interactive information platform, pay attention to popular topics, and receive information from the public. To achieve two-way communication between the government and the public. 3) In the aftermath of a disaster event, it is of utmost important to ensure efficient allocation of emergency resources (e.g. food, water, shelter, medicines) to locations where the resources are needed (Basu. *et. al.*, 2022: 15). In terms of the way of expressing disaster risk, social media data has both professional and scientific way of expressing and emotional expression,

which meets the public's needs for disaster information. The government should make use of the digital application of social media in various aspects such as disaster resource call for post-disaster reconstruction, rescue effect feedback, etc., to provide decision support and program reference for the improvement and optimization of disaster management resources in the future.

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