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# Saving Lives and Changing Minds with Twitter in Disasters and Pandemics: A Literature Review

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**Abstract:** Twitter is a major tool for communication during emergencies and disasters. This study aimed to investigate Twitter use during natural hazards and pandemics. The included studies reported the role of Twitter in disasters triggered by natural hazards. Electronic databases were used for a comprehensive literature search to identify the records that match the mentioned inclusion criteria published through May 2020. Forty-five articles met the selection criteria and were included in the review. These indicated ten functions of Twitter in disasters, including early warning, dissemination of information, advocacy, assessment, risk communication, public sentiment, geographical analysis, charity, collaboration with influencers and building trust. Preventing the spread of misinformation is one of the most important issues in times of disaster, especially pandemics. Sharing accurate, transparent and prompt information from emergency organizations and governments can help. Moreover, analyzing Twitter data can be a good way to understand the mental state of the community, estimate the number of injured people, estimate the points affected by disasters and model the prevalence of epidemics. Therefore, various groups such as politicians, government, nongovernmental organizations, aid workers and the health system can use this information to plan and implement interventions.

**Keywords:** Twitter; disaster; risk reduction; preparedness; response; recovery

## 1. Introduction

All disasters and emergencies are, by nature, chaotic and dynamic (Guha-Sapir et al. 2016). Disasters triggered by natural hazards change the lives of people in seconds and create physical, emotional and social damage. In such a situation, communication is critical in all phases of disaster management (Mukkamala and Beck 2016). In previous decades, people relied on traditional media such as TV, the radio and newspapers for the news. Sharing information was not easy and quick. In the new era, new technologies have given us the ability to communicate with others quickly and interactively. With rapidly evolving smart device technologies, people can now access information in milliseconds just with one click. Online social media such as Facebook and Twitter play a vital role in disaster management in the world and are recognized as the most popular source for receiving information during disasters (Gray et al. 2016; Avasthi 2017). People themselves are the producers and consumers of messages. The number of social media users worldwide, statistically, was determined from 2010

to 2016 with projections until 2021 (Murthy 2018). In January 2020, it was estimated that there are around 3.8 billion social media users around the globe (Kemp 2020). The increased worldwide usage of smartphones and mobile devices has opened up the possibilities of mobile social networks with increased features such as location-based services like Foursquare or Google Now (Houston et al. 2015). Most social networks are also available as mobile social apps, whereas some networks have been optimized for mobile internet browsing, enabling users to comfortably access visual blogging sites via a tablet (Mukkamala and Beck 2016).

Of all the social media networks, Twitter is a particularly great resource for disaster risk management research. Twitter was launched in October 2006 and quickly became the largest microblogging service (Murthy 2018). This study selected Twitter among social networks because it has the world's largest network of users, can publish globally at any moment, allows users to generate content, is not designed exclusively for news releases, as opposed to other service providers, and allows the user to participate actively (Weller et al. 2014). This active participation is possible due to the real-time content and ease in accessing and searching for available information. Twitter is a social networking and microblogging service, enabling users to read and post tweets or short messages. Twitter messages are limited to 280 characters, and users are also able to upload photos or short videos (Murthy 2018). Tweets are posted to a publicly available profile or can be sent as direct messages to other users. Twitter is one of the most popular social networks worldwide. Part of the appeal is the ability of users to follow any other user with a public profile, enabling users to interact with influencers who regularly post on the social media site.

Effective risk communication helps different stakeholders to manage risk more effectively, to assist people at risk and to play a more active role in different stages of disaster management (OECD 2016). The first step to effective risk communication is hazard identification, risk assessment and vulnerability as shown in Figure 1 (OECD 2016). Knowing the risks improves the user's ability to use Twitter. It is then necessary to make policies at various levels to use risk communication and to use the necessary tools, including Twitter, for ongoing planning and evaluation (Palenchar 2010).

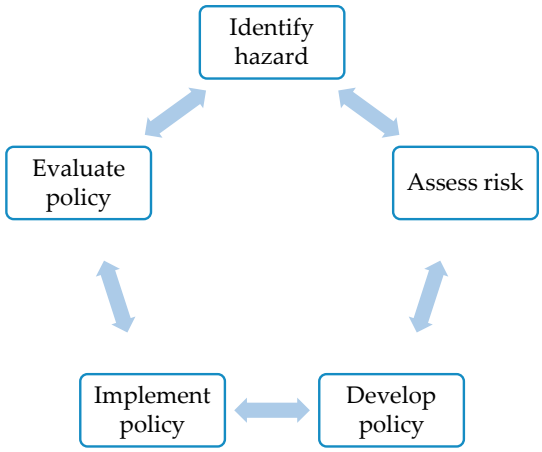


**Figure 1.** The place of risk communication in disaster risk management.

Due to the widespread use of Twitter, various studies have been conducted on the use of this online social network in disasters and pandemics. Deiner et al. (2017) studied public sentiment in response to measles outbreaks through Twitter monitoring (Deiner et al. 2017). They indicated that Twitter could be used as a tool to dispel opposition to vaccination and suggested that health institutions should urgently develop strategies to increase interaction with people through online social media. Tang et al. (2018) reviewed 27 articles about Twitter and outbreaks of emerging infectious diseases such as swine flu, the Ebola virus and bird flu. They observed that Twitter is useful in enhancing the social capital of the health sector (Tang et al. 2018). Predicting disease outbreaks, actionable disease surveillance and outbreak management (Charles-Smith et al. 2015), forecasting the

dynamics of outbreaks (Nsoesie et al. 2014) and detecting public health trends are other functions of Twitter that were not discussed in these studies. It was indicated that Twitter, when used during disasters, can provide useful information to various stakeholders and, given the nature of disasters to which different groups respond, it can be a good tool for sharing information (Abedin et al. 2014; Martínez-Rojas et al. 2018).

With the spread of COVID-19, information and misinformation about it was also spread. Other disasters usually affect a country or a geographical area. However, the global spread of COVID-19 has made Twitter one of the most frequent tools for publishing and looking for information in the world. There have been intense debates about publishing misinformation on Twitter or the impact of Twitter on obtaining health information. By considering pandemics as a disaster, identifying the opportunities and threats of using Twitter as an information exchanging tool can be useful to develop a strategy for disaster risk communication.

This study aimed to show a holistic view of Twitter applications in the disaster management cycle (mitigation, preparedness, response and recovery) and help policymakers, public relations, emergency organizations and other stakeholders to efficiently use Twitter to inform people. To achieve the aim of this research, the following questions are answered by reviewing articles:

1. What are Twitter's functions in a disaster?
2. How can governments and emergency organizations use Twitter to manage disasters more effectively?
3. How was Twitter used at different stages of disaster management including mitigation, preparedness, response and recovery?

## 2. Materials and Methods

### *2.1. Eligibility*

Studies needed to report the role of Twitter in disasters triggered by natural hazards to be included. Those studies that were published in the English language or were presented in conference proceedings and accompanied by full-length peer-reviewed papers were included. The included studies needed to report different functions of Twitter in disaster phases including mitigation, preparedness, response and recovery.

### *2.2. Search Strategy*

Electronic databases including MEDLINE, Web of Science, CINAHL, PsycINFO, Cochrane Register of Controlled Trials (CENTRAL) and EMBASE were used for a comprehensive literature search to identify records that matched the mentioned inclusion criteria and had been published until May 2020. Different keywords for the systematic search were identified during the initial literature search. The main terms were "flood", "hurricanes", "tornadoes", "volcanoes", "earthquakes", "tsunamis", "storms", "emergencies", "crisis", "hazards", "risks", "fire", "bushfire", "landslide", "haze", "sandstorm", "drought", "snowstorm", "heatwave", "cold wave", "severe weather", "avalanche", "thunderstorms", "outbreaks", "Zika", "Ebola", "Flu" and "COVID-19". Search terms were combined with the appropriate Boolean operators and were searched in titles, abstracts and keywords.

### *2.3. Selection Processes*

Two authors participated in the selection process. Endnote desktop was used to store references and subsequently identify and remove duplicates. Two authors then separately scanned the abstracts and full texts to select eligible studies considering the type of interventions, sample population and the reported outcomes.

### *2.4. Data Extraction*

Two authors individually performed data retrieval. The study characteristics extracted from the qualifying studies were the year of publication, findings, disaster phase and geographical location of study conduct.

### *2.5. Data Synthesis*

A narrative synthesis was used for this literature review. Narrative synthesis focuses mostly on the use of words and text to summarize and explain findings (Popay et al. 2006). It is usually viewed as the "second best" approach for synthesis in literature reviews. This approach is a significant method to interpret findings and use in policy and practice.

### *2.6. Search Strategy*

In this literature review, we used a four-step search strategy to identify relevant studies. When potential articles were identified and duplicate articles were deleted, the titles and abstracts of the remaining articles were researched. When an article with the above descriptions was found, the title and summary of the article were reviewed to determine whether the article was relevant to the main purpose of the review. In the case of ambiguity, the full text of the article was also examined. The study was analyzed using the software tool MAXQDA 12 to perform thematic analysis. Then, the two collections of extracted codes were compared, discussed and summarized in ten themes.

## 3. Results

The search resulted in 822 articles, of which 780 articles were removed (256 were not available, 311 were irrelevant, 16 were duplicates and 197 were nonrelated to emergencies). Forty-five articles met the selection criteria and were included in the review. Their characteristics are shown in Table 1. In Figure 2, a word cloud is shown of the reviewed articles' characteristics, including findings, location, disaster and disaster phase.

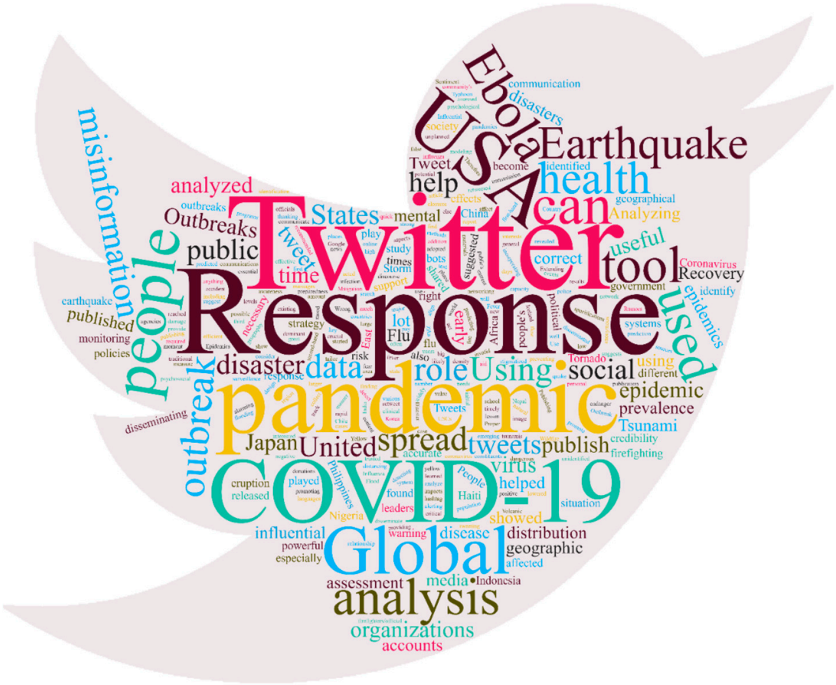


**Figure 2.** Word cloud from reviewed articles' characteristics including type of disaster, phases and countries.

**Table 1.** Characteristics of studies about disasters and Twitter.

| No. | Disaster | Finding | Disaster Phase | Country | Ref. |
|---|---|---|---|---|---|
| 1 | Typhoon | People and organizations have used Twitter more often to retweet second-hand information/social networking users in Philippines are more likely to pay attention to news released in traditional media than social media. | response | Philippines | (Takahashi et al. 2015) |
| 2 | Earthquake, Tsunami | The results suggest that Twitter can be used to track and measure the public's mood after disasters. | Response, Recovery | Japan | (Doan et al. 2011) |
| 3 | Wildfire | The geographic awareness of people is strong about critical events and people are interested in tweeting about fire damage, firefighting and thanking firefighters/official tweets play a key role in the firefighting network. | Preparedness, Response | USA | (Wang et al. 2016) |
| 4 | Earthquake | Rumors about earthquakes spread more than anything else on Twitter. | Response | Chile | (Mendoza et al. 2010) |
| 5 | Earthquake | Twitter was used as a tool to report on the situation by the affected people. This article suggests that Twitter can be used as a tool for rapid assessment of an accident, as well as for the publication of accurate information by officials. | Response | Japan | (Acar and Muraki 2011) |
| 6 | Earthquake | Twitter is useful as a tool to show people's mental health, especially in the early days of a disaster. | Response | Japan | (Cho et al. 2013) |
| 7 | Earthquake | During an earthquake, organizations used Twitter as a tool for risk communication, to collect public donations and to provide psychological support. | Response, Recovery | Haiti | (Gurman and Ellenberger 2015) |
| 8 | Earthquake | Twitter was used for disaster assessment, response monitoring and to help the affected people. | Response | Haiti | (Smith 2010) |
| 9 | Storm | A lot of first-hand information was published about the current situation. Twitter is useful for disaster assessment. | Response | USA | (Mukkamala and Beck 2016) |
| 10 | Tornado | People trusted personal accounts more than governmental accounts to find out about a tornado. Influential people play a big role in providing the right information. Using the right hashtag will help to spread information on Twitter. | Response | USA | (Cooper et al. 2015) |
| 11 | Earthquake | Twitter acted as an effective and efficient tool for communication between people and aid organizations in an earthquake. | Response | Nepal | (Subba and Bui 2017) |
| 12 | Storm | Establishing a strategy for using Twitter in times of disaster is essential. Twitter is a great tool for publishing content, but it has been suggested that influential people should be used to publish it. | Preparedness, Response | USA | (Chatfield and Reddick 2017) |
| 13 | Tsunami | Twitter is a powerful tool for early warning during tsunamis, especially for Indonesia which has a high population distribution. | Preparedness | Indonesia | (Carley et al. 2016) |
| 14 | Volcanic eruption | At the time of the eruption, a lot of misinformation was spread. Therefore, it is necessary for government agencies to have an information strategy in case of disasters so that they can publish the correct information from the first moment. | Response | Iceland | (Sreenivasan et al. 2011) |

**Table 1.** *Cont.*

| No. | Disaster | Finding | Disaster Phase | Country | Ref. |
|---|---|---|---|---|---|
| 15 | Earthquake, Tsunami | A third of the tweets were released from low credibility sources. Tweets published by anonymous and unidentified accounts have lowered credibility. | Response | Japan | (Thomson et al. 2012) |
| 16 | Flood | Tweet analysis helped to identify the effects of flooding on people's mental health. This can affect the design of psychosocial support programs. | Response, Recovery | India | (Karmegam and Mappillairaju 2020) |
| 17 | Ebola Outbreak | To spread information about Ebola, influential people on Twitter shared information. It is recommended that these people be helped to publish correct information. | Preparedness | Global | (Liang et al. 2019) |
| 18 | COVID-19 pandemic | Publishing false information about pandemics has reached alarming levels that endanger public health. | Preparedness | Global | (Kouzy et al. 2020) |
| 19 | COVID-19 pandemic | There was a geographic relationship between the flow of information about the pandemic and the identification of new cases of COVID-19. | Preparedness, Response | Global | (Singh et al. 2020) |
| 20 | COVID-19 pandemic | Using Twitter text and image analysis, the prevalence in each geographical area can be predicted. | Preparedness | Global | (Jahanbin and Rahmanian 2020) |
| 21 | COVID-19 pandemic | Twitter bots are used to promote misinformation and political information about COVID-19. | Preparedness | USA | (Ferrara 2020) |
| 22 | COVID-19 pandemic | At the same time, Twitter played a useful role in promoting positive information and a negative role in disseminating misinformation about the COVID-19. | Preparedness | Global | (Rosenberg et al. 2020) |
| 23 | COVID-19 pandemic | The community's sentiment can be assessed using tweet analysis. | Response | USA | (Medford et al. 2020) |
| 24 | COVID-19 pandemic | Policies adopted in the United States and their effects on society were analyzed using Twitter. | Response | USA | (Sharma et al. 2020) |
| 25 | COVID-19 pandemic | Analyzing the tweets of the leaders of the G7 on the coronavirus showed that Twitter has become a powerful tool for world leaders to disseminate information about public health during the pandemic. | Preparedness | G7 countries | (Rufai and Bunce 2020) |
| 26 | COVID-19 pandemic | Tweet analysis during the COVID-19 pandemic in the United States showed that this pandemic has a political effect on society. Twitter bots played a major role in disseminating invalid information. | Preparedness | USA | (Yang et al. 2020) |
| 27 | COVID-19 pandemic | The dominant discourse in society on the COVID-19 pandemic can be identified and analyzed on Twitter. | Response | Global | (Wicke and Bolognesi 2020) |
| 28 | COVID-19 pandemic | Wrong information was widely published on Twitter. | preparedness | Global | (Sharma et al. 2020) |
| 29 | COVID-19 pandemic | Analyzing Twitter data on the specifications of people with coronavirus, it was suggested that in addition to using clinical data about people with the virus, Twitter data should also be used. | Response | Global | (Sarker et al. 2020) |
| 30 | COVID-19 pandemic | Using tweet analysis in the United States, various aspects of social distancing (methods of preventing infection) were identified and analyzed. | Preparedness | USA | (Kwon et al. 2020) |
| 31 | COVID-19 pandemic | The study found that tweet analysis could be crucial in the geographical distribution and density of the virus outbreak in the UK. | Response | UK | (Golder et al. 2020) |

**Table 1.** *Cont.*

| No. | Disaster | Finding | Disaster Phase | Country | Ref. |
|---|---|---|---|---|---|
| 32 | COVID-19 pandemic | The study found that tweet analysis could help to identify geographic distribution and the prevalence of the virus in the United States. | Response | USA | (Gharavi et al. 2020) |
| 33 | COVID-19 pandemic | Tweet analysis showed that a large number of tweets have stigmatized China because the first cases of this pandemic were observed in China. | Response | USA | (Budhwani and Sun 2020) |
| 34 | Outbreaks | Twitter is useful in predicting disease outbreaks. | Mitigation | Global | (St Louis and Zorlu 2012) |
| 35 | Zika outbreak | Tweets showed the social impacts of the epidemic, the role of organizations and policies, information on the transmission of the disease and the lessons learned. | Preparedness, Response | Global | (Fu et al. 2016) |
| 36 | Flu outbreak | The use of Twitter data is more accurate in modeling flu epidemic prediction than Google data. | Response | USA | (Paul et al. 2014) |
| 37 | Yellow Fever outbreak | The amount of misinformation about yellow fever was much larger than that of correct information, and misinformation was shared and retweeted, which can be dangerous to public health. | Preparedness | Global | (Ortiz-Martínez and Jiménez-Arcia 2017) |
| 38 | Outbreaks | Twitter can act as an early warning system during epidemics. Twitter can also help to detect the prevalence of geography at different times and places and can be analyzed from time to time. | Preparedness | Global | (Kanhabua and Nejdl 2013) |
| 39 | Flu and Ebola Outbreaks | Analyzing tweets about the 2009 and 2014 Ebola epidemics revealed that Twitter could help to analyze the state of mental health and general fear during the epidemic. | Response | Global | (Ahmed et al. 2018) |
| 40 | Ebola outbreak | During the 2014 Ebola outbreak in East Africa, a lot of misinformation was spread on Twitter. Proper information needs to be disseminated through influential people during epidemics. | Preparedness | East Africa | (Oyeyemi et al. 2014) |
| 41 | Flu outbreak | Twitter was used as a tool for early warning during the 2009 flu and risk communications in the United States. | Preparedness | USA | (Kostkova et al. 2014) |
| 42 | Ebola outbreak | Twitter helped to spread information about Ebola in Nigeria. | Preparedness | Nigeria | (Carter 2014) |
| 43 | Outbreaks | The potential value of incorporating Twitter into existing unplanned school closure (USC) monitoring systems was examined. | Response | USA | (Ahweyevu et al. 2020) |
| 44 | Influenza Epidemics | Extending the capacity of surveillance systems for detecting emerging influenza was examined. | Response | Korea | (Woo et al. 2017) |
| 45 | Ebola | Social media can be used to communicate possible disease outbreaks in a timely manner, and using online search data to tailor messages to align with the public health interests of their constituents was considered by government officials. | Preparedness | USA | (Wong and Harris 2017) |

Ten themes were found in the narrative synthesis, including early warning, disseminating information, advocacy, assessment, risk communication, public sentiment, geographical analysis, charity, collaboration with influencers and building trust (Figure 3).

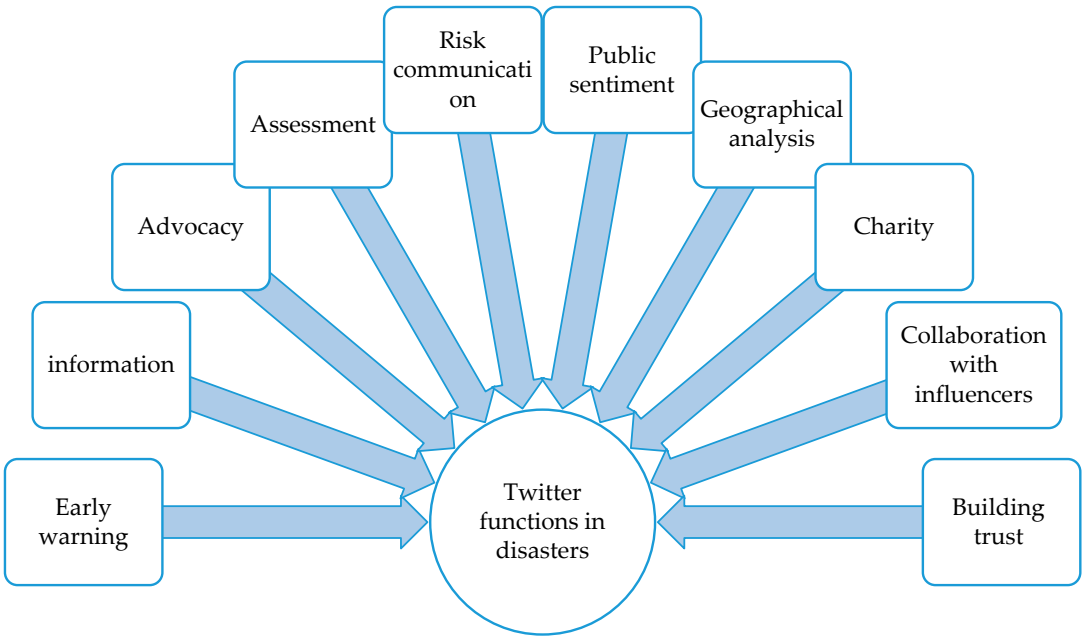


**Figure 3.** Twitter functions in disasters extracted from the literature review.

### *3.1. Early Warning*

One of Twitter's uses in emergencies is to provide an early warning. It has been found that Twitter is useful in predicting disease outbreaks (St Louis and Zorlu 2012). It has also been indicated that Twitter data are more accurate when it comes to modeling flu epidemic prediction than Google data (Paul et al. 2014).

A study conducted in the city of Padang in Indonesia (Carley et al. 2016) found that Twitter was used more than other social networks in the local community context. Based on the study's findings, it was suggested that early disaster warning on Twitter can alert people. Because of the geographic distribution patterns of people, the use of Twitter at different hours of the day and through the weeks can be analyzed. According to the analysis of data extracted from Twitter, authorities can efficiently plan early disaster warnings using Twitter. Considering the multilingual nature of the study area in Indonesia, it was suggested that to provide early warning and inform most of the affected people, there should be tweets in different languages to retweet or share with the local community. Moreover, in another article about the Nepal earthquake (Subba and Bui 2017), it was shown that early warning was one of Twitter's most useful functions in the Nepal earthquake.

### *3.2. Disseminating Information*

One of the challenging issues during the COVID-19 pandemic around the world is spreading information and misinformation. Many reviewed articles mentioned this significant issue in outbreaks and other natural disasters (Smith 2010; Doan et al. 2011; Sreenivasan et al. 2011; Thomson et al. 2012; Cho et al. 2013; Carter 2014; Kostkova et al. 2014; Oyeyemi et al. 2014; Cooper et al. 2015; Takahashi et al. 2015; Fu et al. 2016; Mukkamala and Beck 2016; Wang et al. 2016; Chatfield and Reddick 2017; Ortiz-Martínez and Jiménez-Arcia 2017; Subba and Bui 2017; Ahmed et al. 2018; Ferrara 2020; Golder et al. 2020; Kouzy et al. 2020; Kwon et al. 2020; Rosenberg et al. 2020; Rufai and Bunce 2020; Sarker et al. 2020; Sharma et al. 2020; Wicke and Bolognesi 2020; Yang et al. 2020). It was claimed that publishing misinformation about the COVID-19 pandemic has reached alarming levels that endanger public health (Kouzy et al. 2020). By contrast, some other articles highlighted the importance of disseminating accurate information to people through Twitter and found this social medium a great tool for enhancing public health (Carter 2014; Kostkova et al. 2014; Oyeyemi et al. 2014).

Dissemination is another Twitter application for natural disasters. Subba and Bui showed in their study that Nepal police used Twitter to disseminate information to citizens (Subba and Bui 2017). This included information related to earthquakes in Nepal, including road conditions, flood relief, equipment information, rescue operations, injured and affected people, missing persons, community participation during disasters and public information. Some studies revealed that Twitter users published their environmental information in disaster situations and their first-hand experiences on crisis-related issues.

### *3.3. Advocacy*

Advocacy was another of Twitter's functions. For instance, users became the voice of the people in the Haiti earthquake by criticizing political institutions and sharing the requests of the public. Discussions around legitimizing some of the organization's actions and criticisms of local TV that did not share earthquake news as the first issue were some of the methods used (Smith 2010).

### *3.4. Personal Gains*

Some Twitter users post on Twitter during disasters for personal gain reasons. In a study on the Haitian earthquake (Smith 2010), it became clear that certain Twitter users talked about helping earthquake survivors in order to gain more followers. Certain tweets posted by users contained messages that had been written targeting a specific audience, e.g., posts claiming that if a celebrity (e.g., Justin Bieber) reads their tweets, the user will contribute $10 to Haiti relief operations.

### *3.5. Assessment*

Rapid assessment during the first days after a natural disaster and during the response is vital to improve operations. Some of the reviewed articles mentioned this significant topic as a function of Twitter in natural disasters (Smith 2010; Fu et al. 2016; Ahmed et al. 2018; Golder et al. 2020; Kwon et al. 2020; Sarker et al. 2020; Wicke and Bolognesi 2020). For example, Sarker et al. (2020) found that Twitter data on the characteristics of people infected with COVID-19 were as useful as clinical data (Sarker et al. 2020). Kwon et al. (2020) claimed that using tweet analysis in the United States, various aspects of social distancing (methods of preventing infection) were identified and analyzed (Kwon et al. 2020).

Smith in his study showed that users found an opportunity to discuss the effectiveness and scoring of relief efforts and evaluated the activities of relief agencies (Smith 2010). In another study, Twitter was shown as a tool to quickly assess disaster losses from Hurricane Sandy damage in 53 US metropolises (Kryvasheyeu et al. 2016; Chatfield and Reddick 2017).

### *3.6. Risk Communication*

Many of the reviewed studies emphasized the use of Twitter by government and humanitarian agencies during disasters (Sreenivasan et al. 2011; Cooper et al. 2015; Gurman and Ellenberger 2015; Takahashi et al. 2015; Carley et al. 2016; Fu et al. 2016; Wang et al. 2016; Chatfield and Reddick 2017; Subba and Bui 2017; Sharma et al. 2020). A study about wildfires (Wang et al. 2016) showed that official tweets play a key role in sharing important information about this disaster. For example, certain community elites, such as local authorities and celebrities, are dominant in the information-sharing network (Wang et al. 2016).

The topic of risk communication was investigated in a study on earthquake, tsunami and nuclear incidents in Tokyo (Acar and Muraki 2011). One of the findings was that unreliable retweets are the biggest problem that users were faced with during a disaster. The solution that was offered was the introduction of official hashtags by authorities. In another study about Japan's 2011 earthquake (Cho et al. 2013), it was shown that due to the large number of followers of official government accounts on Twitter, people showed more trust in them. Despite that, in another study about storms in the USA

(Cooper et al. 2015), it was shown that locals were more interested in following the accounts of famous people and preferred to receive less information from government accounts.

A study about the 2010 Haiti earthquake presented various findings on the role of organizations in sharing information on Twitter (Gurman and Ellenberger 2015). The findings of the study indicated that the number of tweets by organizations doubled after the earthquake, which reflects the communication strategy of these organizations, particularly relief organizations. The research also showed that the content varied depending on the organization. For instance, UN agencies made a lot of references to the main relief organizations, as well as shared links to many audio and video files related to the disaster. The study, however, found that the use of links in tweets is not the most effective method, and the researchers indicated that additional steps were needed, such as retweeting and mentioning organizations. These additional steps could provide quick access to the audience. According to the findings of this study, organizations need to use more social networking tools such as Twitter during disasters to provide people with timely and responsive communication regarding the crisis.

Communication on Twitter during a disaster should not just be one-way, however; organizations can also receive information from the public which may prove useful in relief aid. A study (Mukkamala and Beck 2016) on Twitter's role during Hurricane Sandy in the United States showed that during a disaster, ordinary people publish timely information about the unfolding situation, and this information can then be used by emergency organizations.

In a study about the Nepal earthquake (Subba and Bui 2017), it was indicated that police used Twitter for risk communication. The information provided after the Nepal earthquake by the Police Department included general information (about the situation on the roads, about flooding, landslides, emergency kits and equipment, rescue operations, injuries, missing persons, community participation, other general information), warnings (landslide/flood warnings, abuse warnings, public warnings), encouraging words (encouragement to cooperate with rescuers and the police) and efforts to dispel rumors. The study showed that the use of Twitter by the Nepal Police Department after the earthquake was effective and efficient and has been used as a bridge between the public and the authorities. Meanwhile, using Twitter has corrected police priorities in reporting with continuous feedback from people.

In a study about Hurricane Sandy in the United States (Chatfield and Reddick 2017), the importance of organizations using Twitter at various stages of the disaster was highlighted. It is clear that setting up a network of social media in the preparedness phase is vital for the government. Increasing the quality of the content of tweets to improve citizen awareness and to communicate with people on time are two important points to consider in the relationship between government and the general public during a disaster. The government can use social networks to deliver messages in emergencies. One way to achieve this aim is to identify influencers on Twitter with a high number of followers and recruit them to retweet official messages.

### *3.7. Tracking Public Mood*

Another Twitter application during a disaster is measuring the mental state of people. Ahmed et al. (2018) found that analyzing tweets about the 2009 and 2014 Ebola epidemics helped to analyze the state of mental health and general fear during the epidemic (Ahmed et al. 2018.) A study on the Tohoku earthquake in Japan (Doan et al. 2011) showed people's anxiety levels returned to normal after the earthquake. The results suggested that Twitter could be used to track the public mood of populations affected by disasters as well as an early warning system. In another study on the Japanese earthquake (Cho et al. 2013), it was observed that the number of emotional tweets was much higher in the early days after the earthquake and decreased in the following days. Medford et al. (2020) showed that by analyzing tweets in the USA during the COVID-19 pandemic, it was possible to assess the public's sentiments about it (Medford et al. 2020).

### *3.8. Geographical Analysis*

Many of the studies that have been conducted to analyze the use of Twitter during disasters have addressed geographical topics (Acar and Muraki 2011; Kanhabua and Nejdl 2013; Cooper et al. 2015; Takahashi et al. 2015; Wang et al. 2016; Gharavi et al. 2020; Golder et al. 2020; Jahanbin and Rahmanian 2020; Singh et al. 2020). Singh et al. (2020) showed that there was a geographical relationship between the flow of information about the coronavirus pandemic and the identification of new cases of COVID-19 (Singh et al. 2020). Geographical analysis of hurricanes in the Philippines (Takahashi et al. 2015) showed that, as expected, most of the people who tweeted from the Philippines talked about relief, and those who lived outside of the Philippines tweeted in memoriam of the deceased and in support of those affected. Another study in the United States (Wang et al. 2016) showed that there was a relationship between the places where a fire occurred and the location of the tweets associated with the fire. Text mining indicated that people have strong geographical awareness during wildfire hazards and that people are interested in tweeting about wildfire damage, wildfire response and to thank firefighters.

Researchers in another study on the lessons learned from using Twitter during the 2011 tsunami in Japan (Acar and Muraki 2011) showed that the location of a tweet is related to the type of content: people who were tweeting from the affected area of Miagi were more concerned about their safety and about surviving the catastrophe; however, people who had been affected indirectly by the earthquake (Tokyo) used their tweets to report on being safe, as well as to share the materials that needed to be shipped and the dangers of nuclear centers.

Another study about the 2013 Hattiesburg F4 Tornado in the United States (Cooper et al. 2015) suggested that using the geographic tag in tweets can help to save affect people during a disaster if the correct hashtag is used. The study referenced an example of someone who needed help and who published a tweet containing the 911 hashtag, and relief workers were able to rescue them by turning on their mobile location. This highlights Twitter's value in planning, reducing, preparing and responding to disasters.

### *3.9. Charity*

Gathering public donations and contributions for the affected people were another Twitter function that was mentioned in the findings of a study. This study (Gurman and Ellenberger 2015), focused on the Haiti earthquake, indicated that the rapid use of Twitter improved the quality and quantity of donations for the Haitian people. In another study on the Haiti earthquake (Smith 2010), it was observed that some people believed donations should be made through official channels only, while others introduced different, informal methods to donate. In another study on Japan's earthquakes (Cho et al. 2013), it was found that Twitter was used for communication about earthquake survivors' information, disaster information for foreigners, photo and video sharing and donations.

### *3.10. Collaboration with Influencers*

Many of the studies have addressed the role of famous people or influential users on Twitter at the time of disaster (Mendoza et al. 2010; Oyeyemi et al. 2014; Cooper et al. 2015; Takahashi et al. 2015; Carley et al. 2016; Chatfield and Reddick 2017; Liang et al. 2019). Liang et al. (2019) discussed the role of influential people on Twitter retweeting to share information about Ebola (Liang et al. 2019). They recommended that officials should support influential users and help them to publish correct and confirmed health information. A study on Twitter's role in the Typhoon Haiyan (Takahashi et al. 2015) showed that various Twitter users posted different information based on their traditional position. For instance, journalists and news agencies published second-hand news, celebrities wrote more emotional messages that included memorials and NGOs focused on issues such as the coordination of relief efforts. In the same study (Takahashi et al. 2015), a Chi-square analysis revealed an important and influential category of users. For example, officials and organizations can use Twitter for relief coordination, while celebrities, using their many followers, are active in

advertising for donations. Another study on wildfires (Wang et al. 2016) found that official tweets play a key role in the firefighting network. For instance, some community elites, such as local authorities and media representatives, dominate the information republishing network and play an important role. The study (Cooper et al. 2015) revealed that many sports journalists who were skilled in tweeting and had tweeted before the storm did not publish much after the storm. Similarly, spiritual and religious leaders with many followers were not active on Twitter after the storm. The authors of the study suggested that raising awareness of their ability to help among influential users will be helpful. A study on Hurricane Sandy in the United States (Chatfield and Reddick 2017) showed that identifying and seeking the help of Twitter users with the most followers is a quick way to attract people's attention to public messages. In a study in Indonesia (Carley et al. 2016), it was pointed out that the Twitter activities of intellectual leaders across different age groups of users were effective.

### *3.11. Building Trust*

One of the points that were highlighted in the study was the trust of people in the content posted on Twitter in times of disaster. It seems that social trust is different in different countries. In a paper on Typhoon Haiyan (Takahashi et al. 2015) in the Philippines, it was highlighted that Twitter users in the Philippines are more likely to value traditional media over social networks, and this may be due to the volume of rumors on social networks, which leads to more trust in news sources. Findings from a study on Japan's earthquakes (Cho et al. 2013) showed that Japanese government officials had a large number of followers on Twitter, which shows people's trust in relief organizations' pages in this social network. In a further study on a Chilean earthquake (Mendoza et al. 2010), it was shown that rumors were questioned more on Twitter than confirmed facts. Results of a study on Japan's 2011 tsunami (Acar and Muraki 2011) about misinformation from informal sources indicated that users recommended using official hashtags to track information. Some believed that the government should be more active in providing accurate information, and some users believed that Twitter could add some features to this application to make it more effective in such circumstances.

Findings from a study on Fukushima's nuclear incident (Thomson et al. 2012) indicated that one-third of the tweets were released from low credibility sources. Given the large number of unofficial accounts of Japanese users, it was expected that more misinformative tweets by such users in Japan would be published, but the findings did not show that most of the content was tweeted by Japanese users, which may be due to their proximity to the incident and their sense of responsibility. Sreenivasan et al. (2011) in their study (Sreenivasan et al. 2011) suggested that due to the prevalence of using Twitter in various eruptions of volcanoes, different organizations should send different information at the moment of the incident on Twitter, to reduce misinformation.

### *3.12. Other Issues*

Other issues that Twitter users have encountered during disasters include memorials for affected people, relief coordination (Smith 2010; Carley et al. 2016; Mukkamala and Beck 2016), psychosocial support (Takahashi et al. 2015) and thanks aimed at relief workers (Wang et al. 2016).

## 4. Discussion

The findings in this study indicated that Twitter can have many functions in disaster management, including early warning, disseminating information, advocacy, rapid assessment, risk communication, public sentiment, geographical analysis, supporting charity, informing people in collaboration with influencers and building trust. However, the reviewed articles mostly emphasized the response during disasters triggered by natural hazards. Mitigation and preparedness are two important phases that result in disaster risk reduction (Seddighi 2020). Social media functions during disasters were categorized into three phases, including pre-event (mitigation and preparedness), event (response) and post-event (recovery) (Houston et al. 2015). The social media functions during the pre-event phase are disaster warning, disaster detection and crisis communication. In the post-disaster phase,

social media are used to document the disaster and the lessons learned, to deliver news, response information, send and receive donations, raise awareness, offer mental health support, express emotions, memorialize victims and share stories. Reconnecting community members and discussing the disaster happen in the post-event phase (Houston et al. 2015). Disasters can impose very high costs on countries. Disasters create a poverty trap or generational poverty in lower-income countries that are prone to a variety of disasters.

During disasters, many stakeholders—such as affected people, journalists, authorities and humanitarian organizations—collaborate with each other in their response (Seddighi et al. 2020). Communication tools including Twitter could be used for various purposes in that effort. Many of the reviewed papers discussed the importance of officials, relief organizations and other main organizations using Twitter. Timely and prompt action in the event of a disaster to provide accurate information reduces the flow of misinformation and anxiety and increases trust. Additionally, using Twitter has been found to result in receiving feedback from people in organizations and in the modification of operations and programs based on that feedback (Mora et al. 2015; Pourebrahim et al. 2019). Twitter can be used to share information with the general public around the situation on roads, as well as about flooding, landslides, relief and rescue operations, missing people and risk alerts (Kankanamge et al. 2020). One of the most effective ways to disseminate important information in emergencies is identifying influencers on Twitter (Heidari et al. 2018; Yang et al. 2019). This can help official information to be retweeted faster and to reach more people. The role of celebrities, famous people who are active on Twitter, is pivotal during a disaster. The role of influential users in risk communication via Twitter in times of disaster was highlighted in various of the reviewed studies. Famous people are active in promoting philanthropic propaganda, and studies have suggested that humanitarian and governmental institutions can identify people who are influential on Twitter (religious, sports, entertainment, etc.) and recruit them to share information at times of disaster.

Some studies suggested that Twitter can serve as an early disaster warning system since people's geographic distribution patterns make daily and weekly Twitter use more accessible and allow authorities to plan early disaster warning with higher effectiveness by paying attention to this information.

The evaluation of relief efforts was a function that was addressed. Through Twitter, users found the opportunity to discuss and assess the efficiency of relief efforts, as well as to evaluate relief programs. Early and rapid assessment of disasters and emergencies can help to increase the involvement of different groups and can lead to more efficient responses (Kitazawa and Hale 2020). In emergencies, optimal resource allocation is one of the key issues around equal access to vital resources. Due to various factors, such as limited resources, short time for needs assessment, the possibility of unrest in the case of unequal access and prolonged response time (such as with the COVID-19 pandemic), rapid assessment and evaluation of interventions are of great importance. Emergency organizations and governments are always using various tools for rapid assessment and evaluation of interventions, and Twitter can be used as a way to gather valuable information.

Disaster analysis is possible from a geographic perspective on Twitter, and it was found in the reviewed studies that using the geolocation option when tweeting could help to save people. One of the papers suggested that using proper hashtags help to save people during disasters. The study referenced an example of someone who needed help and who published a tweet containing the 911 hashtag, and relief workers were able to rescue them by turning on their mobile location. This highlights Twitter's value in planning, reducing, preparing and responding to disasters. Another use of Twitter that was mentioned in the reviewed studies was in the provision of relief assistance and substantial financial contributions.

One of the concerns raised in this review was trust in the content posted on Twitter in times of disaster, and we found that this varied among different countries. Low levels of trust within and between various groups in disasters such as the general public, the government, civil society organizations and emergency organizations can cause relief operations to fail (Salmani et al. 2020).

In countries where there is a high degree of trust in government agencies and aid workers, it is recommended that these institutions publish information related to the disaster sooner than other sources. Studies also showed that rumors and misrepresentation on Twitter are questioned by users, and people can actively participate in questioning misconceptions and republishing correct or formal content. On the topic of social trust, the theory of risk communication was emphasized in the studies, which states that if people do not trust an organization or institution, negative information will increase distrust. Moreover, trust in an organization can be destroyed through misinformation much more quickly than it can be built (Regina and Andrea 2018).

Upon reviewing the content of the studies selected, we found that the results suggested that Twitter can be used to track and measure the public mood of people after disasters, which could be used to design post-disaster psychosocial support programs. The mental health of affected people is one of the cases where timely response can help to prevent long-term damage to people's health at both the individual and social levels (Seddighi et al. 2020). One of the major concerns of governments in the coronavirus pandemic is the mental health of people during quarantine (Alkhayyat and Pankhania 2020; Hansel et al. 2020). Mental disorders have also been reported among people who have fallen ill or recovered. One of the reviewed articles showed that Twitter can be one of the best tools for designing psychosocial interventions (Takahashi et al. 2020).

Advocacy was another issue that was taken into consideration in the reviewed studies. During disasters, vulnerable groups such as migrants, children, the elderly and ethnic minorities are most at risk. Therefore, advocating for these groups can make their voices heard by government officials and aid organizations. A study on an earthquake showed that some Twitter users were able to track the situation of the affected people, source relief items, discuss the legitimacy of certain organizations' actions and criticize local television stations which were not giving priority to reporting earthquake news.

Based on the various findings discussed, the following framework can be suggested for the use of Twitter during disasters. The findings show that the key axes of risk communication via Twitter in disasters are five subjects, i.e., stakeholders, type of hazards, Twitter functions, tweet characteristics and disaster risk management. These include both stakeholders and messages. Table 2 presents the identified axes along with examples extracted from the review articles.

**Table 2.** A framework for using Twitter during disasters.

| Stakeholders | Type of Hazards | Twitter Functions | Tweets Characteristics | Disaster Risk Management |
|---|---|---|---|---|
| Governments, Emergency organizations, Celebrities, People, News agencies, Donors, Affected people | Disasters triggered by natural and technological hazards, pandemics and complex disasters | Early warning, disseminating information, advocacy, assessment, risk communication, public sentiment, geographical analysis, charity, collaboration with influencers and building trust | Transparency, on-time messages, using different local languages, Using different media (text, video, photo) | Using Twitter during different phases including mitigation, preparedness, response and recovery |

## 5. Conclusions

It is recommended that influential individuals be identified in each country and community before disasters occur so that the necessary information can be disseminated in response to disasters. Preventing the spread of misinformation is one of the most important issues in times of disaster, especially pandemics. Disseminating accurate, transparent and prompt information to relief organizations and governments can help. Furthermore, analyzing Twitter data can be a good source to understand the mental state of the community, estimate the number of injured people, estimate who and what is affected by a natural disaster and model the prevalence of epidemics. Therefore, various groups such as politicians, government, nongovernmental organizations, aid workers and the health system can use this information to plan and implement interventions.

### *5.1. Implications for Practice*

It is proposed to humanitarian organizations and governments to use Twitter as an early warning and communication tool. Using multilingual messages to raise awareness and provide early warning in multicultural and multilingual countries will improve crisis communication. Moreover, using Twitter as a medium to provide warning about risks and encourage the public (e.g., to participate in recovery efforts) will be useful during disasters. Organizations can "hear" the voice of the people on Twitter and use it as an evaluation tool. In addition to messages from official accounts, organizations should use famous people and influencers to share their messages with the people. Organizations should tweet on time and in a clear manner during a disaster to counteract fake news. Using Twitter to track public mood can help the government to better plan for psychosocial support during disasters. In addition, geolocation data extracted from Twitter can help authorities to plan a better response to disasters.

### *5.2. Implications for Policy*

It is recommended that governments make plans to use Twitter in the preparedness, response and recovery stages of a disaster, as it can enhance their communication strategy. Governmental and emergency organizations should also make plans to identify influencers on Twitter in order to better share on-time and correct messages to achieve efficient preparedness for, response to and recovery from disasters.

### *5.3. Implications for Research*

Researchers should focus more on Twitter use in neglected disasters such as floods and certain disaster-prone countries such as Iran, Pakistan, South Africa, etc. In addition, Twitter's functions divided by gender and other characteristics that show the diversity of its users can help to identify the patterns of Twitter use during a disaster and help the responsible organizations to better plan for future disasters.

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