SYSTEMATIC REVIEW

Social Media Use in Emergency Response to Natural Disasters: A Systematic Review With a Public Health Perspective

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ABSTRACT

Social media research during natural disasters has been presented as a tool to guide response and relief efforts in the disciplines of geography and computer sciences. This systematic review highlights the public health implications of social media use in the response phase of the emergency, assessing (1) how social media can improve the dissemination of emergency warning and response information during and after a natural disaster, and (2) how social media can help identify physical, medical, functional, and emotional needs after a natural disaster. We surveyed the literature using 3 databases and included 44 research articles. We found that analyses of social media data were performed using a wide range of spatiotemporal scales. Social media platforms were identified as broadcasting tools presenting an opportunity for public health agencies to share emergency warnings. Social media was used as a tool to identify areas in need of relief operations or medical assistance by using self-reported location, with map development as a common method to visualize data. In retrospective analyses, social media analysis showed promise as an opportunity to reduce the time of response and to identify the individuals' location. Further research for misinformation and rumor control using social media is needed.

Key Words: disaster, emergency, response, social media

The Centers for Disease Control and Prevention (CDC) defines a disaster as a disruption in society and lives of the population, causing material, human, or environmental losses.[1] During natural disasters, emergency management organizations take actions to work and avoid risks caused by the event.[2] The emergency management response to these events is divided into 4 phases: mitigation, preparedness, response, and recovery. Each of these phases targets a specific time point of the emergency where decisions are made to prepare for the event, respond to damage or danger, and help those affected to return to normality.[2] In this review article, we are primarily interested in the application of social media resources during the response phase, which is a dynamic process that includes immediate actions to save lives, property, and environment for short-term recovery.[3,4] During the response phase, effective coordination, information, and communication can ensure the safety of all affected individuals.[4]

In recent years, researchers proposed the use of social media for public health surveillance and during natural disasters.[5,6] From 2005 to 2018, the use of social media in the United States increased from 16% to 88% among those aged 18-29 and from 9% to 78% in those aged 30-49.[7] Social media platforms offer its users a tool to communicate emergency information, warnings, and updates using short messages, photos, and videos.[5,8] The opportunities provided by social media research, such as classification of information, identification of individuals in need, and affected areas, reflect the need for understanding the use of social media in an emergency response.[9-12]

The purpose of our review is to study the implications of social media use during natural disasters. We explored peer-reviewed publications since 2015 that focus on the public health implications of social media platforms. We seek to add to a systematic review, previously published by Finch et al.,[5] that summarized the literature published up to January 30, 2015, on the implications for social media use during natural disasters and emergencies. Compared to previously published reviews on the topic,[5,13-15] our review provides more recent literature on social media use during natural disasters, focusing on the utility public health practitioners can gain from including social

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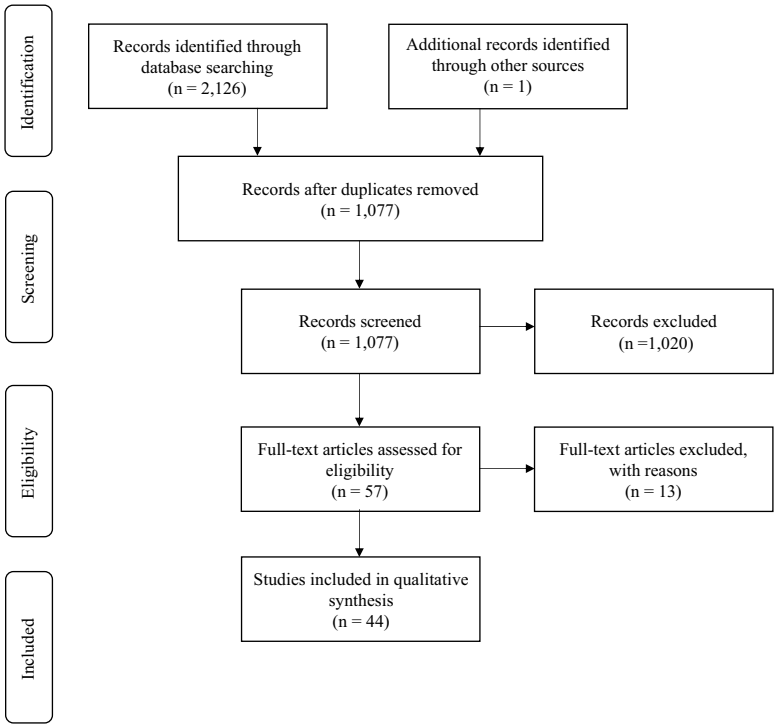
FIGURE 1

PRISMA flowchart for the systematic review for social media use during the response phase of emergency management: a public health perspective



media data analysis in the response phase to these events in hopes of facilitating decision-making during the response phase to a natural disaster. Our research objectives include assessing (1) how social media improved the dissemination and distribution of emergency warnings and response information during and after a natural disaster, and (2) how social media data analysis contributed to the identification of physical, medical, functional, and emotional needs after a natural disaster.

METHODS

Eligibility Criteria

This systematic review was conducted following PRISMA guidelines.[16] Our process included: identification of records in bibliographic databases, screening of titles and abstracts for relevance, full-text screening for eligibility, data extraction, and data analysis (Figure 1). Articles determined eligible for the study were original research published in peer-review journals. Human-made disasters (eg, chemical spills) were deemed out-of-scope. Research articles were related to natural disasters, emphasizing the use and analysis of data from social media platforms. Research articles needed to be available in full-text and written in either English or Spanish.

Information Sources

Three bibliographic databases, PubMed, Web of Science and IEEE Xplore, were searched on September 18, 2018. The search strategy included articles published from January 1, 2015, to September 18, 2018, to update and add to the previously published systematic review by Finch et al.[5] who summarized the literature on the use of social media during a natural disaster and emergency events up to January 30, 2015. Differing from Finch et al.,[5] our search strategy includes a database targeted to computational sciences and different key words for searches that allowed the identification of research articles in wide number of investigation fields.

The key words for data retrieval were: "social media", "natural disaster*", "natural hazard*", emergency*, and crisis*. The bibliographic records of 2126 articles were downloaded from the key word searches. The search strategy and key word combinations used are specified in the supplementary materials.

Study Selection

After removal of duplicates, 1077 articles were identified for screening. K.M.R. first screened the titles and abstracts for relevance. Articles mentioning the study of natural disasters and social media for emergency management were included for a

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second screening process. Titles and abstracts of 108 articles were screened in duplicate by K.M.R. and S.K.O. to determine if the full-text of the research publications should be downloaded for the data collection process. Following the screening, a total of 57 full-text articles were retrieved to extract the data items of interest. After assessing the eligibility of each full-text article, a total of 44 publications were included in this systematic review (Figure 1).

Data Collection

Two groups of co-authors, with 2 members each, were assigned articles for data extraction (Group 1: K.M.R. and M.L., Group 2: S.K.O. and K.D.). The reviewers determined if the article should be included based on the eligibility criteria. In the event the 2 co-authors did not agree on the inclusion of a research article, a decisive vote was cast by a third co-author (K.M.R. or S.K.O.). Thirteen articles excluded after full-text retrieval are listed in Supplemental Table S1, with reasons for exclusion. Due to the descriptive nature of the articles included for this review, a quality assessment for the publications was not performed.

RESULTS

A total of 44 articles were included in the systematic review. Of these, 19 answered the first research question, 31 answered the second research question, and 6 contributed to the analysis for both (Tables 1 and 2). The methods implemented in the articles included social network analysis (SNA), sentiment analysis, content analysis, semantic analysis, and mapping systems. SNA allows mapping and measuring relationships, and interactions between individuals in a community (Supplemental Figure S1).[17] Sentiment analysis classifies and quantifies the emotions in an analyzed text as negative, neutral, or positive.[18] Content analysis transforms textual data into digital form to examine a topic of interest.[19] Semantic analysis is a type of content analysis that infers the meaning of a message to recognize patterns or relationships.[20] Maps can be developed using social media posts' geolocation to detect damage or situational awareness of those affected by disasters.[21-24]

CAN SOCIAL MEDIA ANALYSIS IMPROVE THE DISSEMINATION AND DISTRIBUTION OF EMERGENCY WARNINGS AND RESPONSE INFORMATION DURING AND AFTER A NATURAL DISASTER?

Social media data analysis, through content, sentiment, and social network analyses, can be included in communication strategies for the dissemination and distribution of warnings and relief information. These methods allow the recognition of posting behavior and message characteristics that can help target a specific audience.[8,25-29] The outcomes can help identify common and less frequent topics that need to be emphasized during the response to events guiding the development of communication strategies and posting time.[8,10,26,30-41]

Application of Content Analysis for Natural Disasters

Effective communication requires identifying the target audience, selecting effective channels to deliver information, monitoring the outcomes of the message, and gathering feedback from the targeted audience.[42] Several studies focused on the use of social media as a tool for delivering emergency warnings and disseminating information related to natural disaster response (Table 1). Content analysis was 1 of the techniques implemented to study information dissemination and early emergency warnings. This research technique can help detect that important topics that should be disseminated during the response to a natural disaster are being discussed by social media platforms users. Analysis of Twitter accounts during the Boulder, Colorado, floods showed that only 6% of the analyzed tweets were health-related posts regarding drinking water safety, floodwater exposure, cleaning, and hygiene, despite the existence of water advisory warning.[26] Authorities during the South Carolina floods of 2015 used Twitter to bring attention to reducing health threats, devastation to structures, resource distribution, appreciation, and fund-raising.[32] However, social media engagement from official agencies using multiple platforms is required for an effective conversation and integration of communities.[27]

Application of Social Network Analysis for Natural Disasters

SNA sought to understand and observe how the connections between individuals affect their relationships or behaviors and how information disseminates among the users of the platform.[8,25,43] In 4 articles, SNA showed citizens were consistently the most active Twitter users during disasters of different natures.[30-33] Twitter was identified as a broadcasting tool to disseminate information related to weather conditions, avoiding threats, providing warnings, information about policies, and correcting misinformation during several natural disasters.[29,31,32,34,35,9,41] SNA of Weibo during the 2012 Yiliang earthquake allowed researchers to detect smaller networks focused on specific topics, such as personal information, caution and advice, casualties and damage, donations, and request for help.[36] Similar results were reported during the 2013 floods in Germany where Facebook and Twitter were used to organize help, volunteers, and share updates.[35]

Research found that SNA can be included in communication efforts during the response to natural disasters. SNA can help communication specialists learn what features of social media can be included in messages, and the time they can reach a higher number of users. SNA for Hurricane Sandy revealed information could be disseminated more extensively by using the retweet function of Twitter, but most of the retweets happened an hour after sharing the original content, which exemplifies the need of using the correct channels for communication.[10] Social media posting frequencies need to be considered for analyses. During Typhoon Haiyan and Storm Cindy tweets peaked on the day of the landfall.[8,37] Limited tweets

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TABLE 1

Can Social Media Assist With Dissemination and Distribution of Emergency Warnings and Response Information During and After a Natural Disaster?

Author(s) (Year)	Topic	Communication	Platform	Event	Location	Continent
Albris, K. (2017)[29]	C	Both	Facebook	2013 Floods in Dresden	Germany: Dresden	Europe
Brandt, H. M., Turner-McGrievy, G., Friedman, D. B., Gentile, D., Schrock, C., Thomas, T., & West, D. (2018)[32]	C, N	One-way communication	Twitter	South Carolina Floods 2015	USA: South Carolina	North America
Cooper, G. P., Jr., Yeager, V., Burkle, F. M., Jr., & Subbarao, I. (2015)[38]	N	One-way communication	Twitter	Hattiesburg F4 Tornado 2013	USA: Mississippi	North America
David, C. C., Ong, J. C., & Legara, E. F. (2016)[37]	C, N, S	One-way communication	Twitter	Typhoon Haiyan 2013	Philippines	Asia
Grasso, V., & Crisci, A. (2016)[31]	C, N	One-way communication	Twitter	Severe weather (flooding) 2014	Italy: Liguria, Tuscany, Southern Piedmont	Europe
Huang, Q., & Xiao, Y. (2015)[39]	C	One-way communication	Twitter	Hurricane Sandy 2012	Downtown New York	North America
Kaufhold, M.-A., & Reuter, C. (2016)[35]	C, N	Both	Facebook and Twitter	2013 European Floods in Germany	Germany: Saxony-Anhalt, Lower Saxony, Bavaria	Europe
Kim, J., & Hastak, M. (2018)[25]	N	Both	Facebook	Louisiana Floods in 2016	USA: Louisiana	North America
Kim, J., Bae, J., & Hastak, M. (2018)[8]	N	One-way communication	Twitter	Tropical Storm Cindy 2017	USA	North America
Li, L., Zhang, Q., Tian, J., & Wang, H. (2018)[36]	C, N	Both	Weibo	Yiliang Earthquake 2012	China	Asia
Pohl, D., Bouchachia, A., & Hellwagner, H. (2016)[40]	M		Twitter, YouTube, Flickr	Hurricane Sandy 2012	USA: Manhattan, New Jersey, Brooklyn	North America
Ramirez Plascencia, D., & Ramirez Plascencia, J. (2017)[33]	C, N	One-way communication	Facebook and Twitter	Hurricane Patricia in 2015	Mexico	North America
Scott, K. K., & Errett, N. A. (2018)[28]	C, N	Both	Facebook and Twitter	Louisiana Floods in 2016	USA: Louisiana	North America
Stephenson, J., Vaganay, M., Coon, D., Cameron, R., & Hewitt, N. (2018)[41]	C	One-way communication	Facebook and Twitter	Floods in Northern Ireland	Ireland	Europe
Sutton, J., League, C., Sellnow, T. L., & Sellnow, D. D. (2015)[26]	C	One-way communication	Twitter	Boulder, Colorado floods 2013	USA: Colorado	North America
Tang, Z., Zhang, L., Xu, F., & Vo, H. (2015)[27]	C	Both	YouTube, Facebook and Twitter	California drought in 2014	USA: California	North America
Wang, Z., Ye, X., & Tsou, M.-H. (2016)[30]	C, N	One-way communication	Twitter	San Bernardo and San Marcos wildfire 2014	USA: California	North America
Wang, B., & Zhuang, J. (2017)[10]	N	Both	Twitter	Hurricane Sandy in 2012	USA	North America
Yi, C. J., & Kuri, M. (2016)[34]	C, N	Both	Facebook and Twitter	Great East Japan Earthquake 2011 and Typhoon Haiyan 2013	Philippines and Japan	Asia

Abbreviations: C, content analysis; M, maps or locations; N, network analysis; S, sentiment analysis.

TABLE 2

How Can Social Media Data Analysis Contribute in the Identification of Physical, Medical, Functional, and Emotional Needs After a Natural Disaster?

Author(s) (Year)	Topic	Platform	Event	Location	Continent
Albris, K. (2017)[29]	C	Facebook	2013 floods in Dresden	Germany: Dresden	Europe
Andrews, S., Gibson, H., Domdouzis, K., & Akhgar, B. (2016)[56]	C	Twitter	Nepal earthquake 2015	Nepal	Asia
Avvenuti, M., Cimino, M. G., Cresci, S., Marchetti, A., & Tesconi, M. (2016)[24]	M	Twitter	Earthquakes	Italy	Europe
Avvenuti, M., Cresci, S., Del Vigna, F., & Tesconi, M. (2016)[23]	C, M	Twitter	L'Aquila earthquake (Italy), Emilia earthquake, Sardegna (Sardinia)	Italy	Europe
Avvenuti, M., Cresci, S., La Polla, M. N., Meletti, C., & Tesconi, M. (2017)[59]	M	Twitter	Earthquakes		North America, Central and South America, Rest of the world
Bai, H., & Yu, G. (2016)[46]	S	Weibo	Ya'an earthquake 2013	China	Asia
Brandt, H. M., Turner-McGrievy, G., Friedman, D. B., Gentile, D., Schrock, C., Thomas, T., & West, D. (2018)[32]	C, N	Twitter	South Carolina Floods 2015	USA: South Carolina	North America
Cervone, G., Sava, E., Huang, Q., Schnebele, E., Harrison, J., & Waters, N. (2016)[22]	C, M	Flickr and Twitter	Boulder, Colorado flood 2013	USA: Colorado	North America
Comunello, F., Parisi, L., Lauciani, V., Magnoni, F., & Casarotti, E. (2016)[50]	C, N	Twitter	Emilia seismic sequence 2012	Italy	Europe
David, C. C., Ong, J. C., & Legara, E. F. (2016)[37]	C, N, S	Twitter	Typhoon Haiyan 2013	Philippines	Asia
de Albuquerque, J. P., Herfort, B., Brenning, A., & Zipf, A. (2015)[48]	C	Twitter	Elbe River Floods 2013	Germany	Europe
Deng, Q., Liu, Y., Zhang, H., Deng, X., & Ma, Y. (2016)[20]	C (Semantic analysis)	Weibo	Typhoon Haiyan 2013	Philippines: Guiuan China: Guangxi and Hainan	Asia
Fohringer, J., Dransch, D., Kreibich, H., & Schroeter, K. (2015)[60]	M	Flickr and Twitter	Dresden floods 2012	Germany: Dresden	Europe
Gul, S., Shah, T. A., Ahad, M., Mubashir, M., Ahmad, S., Gul, M., & Sheikh, S. (2018)[54]	S	Twitter	Jammu and Kashmir floods 2014	India	Asia
Kiatpanont, R., Tanlamai, U., & Chongstitvatana, P. (2016)[11]	Data management, C	Twitter	Thailand flood of 2011	Thailand	Asia
Kryvasheyeu, Y., Chen, H., Obradovich, N., Moro, E., Van Hentenryck, P., Fowler, J., & Cebrian, M. (2016)[49]	S	Twitter	Hurricane Sandy 2012	USA: New Jersey and New York	North America
Li, Z., Wang, C., Emrich, C. T., & Guo, D. (2017)[61]	M	Twitter	South Carolina Floods 2015	USA: South Carolina	North America
Nath, R. N., Priya, N., & Robin, C. R. R. (2017)[45]	S	Twitter	Chennai Floods 2015	India	Asia
Pohl, D., Bouchachia, A., & Hellwagner, H. (2016)[40]	M	Twitter, YouTube, Flickr	Hurricane Sandy 2012	USA: Manhattan, New Jersey, Brooklyn	North America
Ragini, J. R., Anand, P. M. R., & Bhaskar, V. (2018)[55]	S	Twitter	India-Pakistan floods in September 2014, severe cyclonic storm HUDHUD in 2014, and Nilofar		Asia

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TABLE 2

Continued

Author(s) (Year)	Topic	Platform	Event	Location	Continent
Resch, B., Uslander, F., & Havas, C. (2018)[21]	C, M	Twitter	Napa earthquake 2014	USA: California	North A"merica
Sherchan, W., Pervin, S., Butler, C. J., Lai, J. C., Ghahremanlou, L., & Han, B. (2017)[58]	C, M	Instagram and Twitter	Multiple natural disasters	Australia	Australia
Tang, Z., Zhang, L., Xu, F., & Vo, H. (2015)[27]	C	YouTube, Facebook and Twitter	California drought in 2014	USA: California	North America
Tim, Y., Pan, S. L., Ractham, P., & Kaewkitipong, L. (2017)[53]	C	YouTube, Facebook and Twitter	Thailand Floods 2011	Thailand	Asia
Wang, Y., & Taylor, J. E. (2018)[62]	S	Twitter	South Napa Earthquake 2014	USA: California	North America
Wang, Z., Ye, X., & Tsou, M.-H. (2016)[30]	C, N	Twitter	San Bernardo and San Marcos wildfire 2014	USA: California	North America
Wu, D., & Cui, Y. (2018)[18]	S	Twitter	Hurricane Sandy in 2012	USA: New York and New Jersey	North America
Xu, Z., Zhang, H., Sugumaran, V., Choo, K.-K. R., Mei, L., & Zhu, Y. (2016)[57]	C, M	Weibo	Typhoon Chan-hom 2015	China: Zhejiang, Jiangsu, Shanghai, and Beijing	Asia
Yuan, F., & Liu, R. (2018)[47]	C (Semantic analysis)	Twitter	Hurricane Matthew	USA: Florida	North America
Zahra, K., Ostermann, F. O., & Purves, R. S. (2017)[51]	N	Twitter	Earthquakes	Myanmar and Italy	Asia and Europe
Zou, L., Lam, N. S. N., Cai, H., & Qiang, Y. (2018)[52]	S	Twitter	Hurricane Sandy 2012		North America

Abbrevbiations: C, content analysis; M, maps or locations; N, network analysis; S, sentiment analysis.

were collected up to 48 h after landfall of the typhoon, and during Storm Cindy, Twitter interest disappeared 10 days after the event.[8,37] It was also observed that when other simultaneous national events occurred, interest in natural disasters decreased.[25]

SNA permits the recognition of changes in the information that social media users are sharing or seeking. Before a natural disaster takes place, social media users are more inclined to post messages related to information about the event and disaster relief.[36,37] SNA also showed that, when no severe weather warning is active, social media activity is low.[31] The results from these publications emphasize the usefulness of SNA to detect when platforms users are active, and when a warning or disaster response information can be shared to capture the attention of a broader number of users. SNA can help with the construction of messages tailored to answer the questions of affected individuals. These messages should include an imperative and declaratory style, which is essential for health promotion during disasters, and a hashtag to categorize messages under a topic.[26,37] Consistency in hashtag use can help with information dissemination and identification of those in need.[31,38] An essential part of the health communication cycle tailoring messages for the intended audience and adopting appropriate channels for delivery.[42] SNA allowed the recognition of the preferences in social media platforms of individuals affected by natural disasters. During the 2015 Hurricane Patricia in Mexico, researchers observed emergency response agencies used Twitter to provide official messages, but citizens shared the tweets on Facebook where they went viral.[33]

Identification of the target population is essential for successful message dissemination.[42] One way of sharing information with a large number of users is by identifying social media influencers. Influencers are opinion leaders with accounts that have large numbers of followers, messages, and likes, that have the power to influence followers.[44] Social media data analysis was used to identify influencers in the affected area before and after events.[38] Four articles identified individuals as the most prominent users of social media;[30-33] 3 identified news or media, nonprofit organizations, and government agencies as key accounts for information dissemination during natural disasters.[10,25,40] These influential accounts can be used as a channel to share relevant information and emergency warnings to the affected population considering the trends of information changes in social media. However, identifying these accounts before the event takes place can present a challenge for emergency management officials, and a time-consuming one if they are identified during the response to a natural disaster.

HOW CAN SOCIAL MEDIA DATA ANALYSIS CONTRIBUTE IN THE IDENTIFICATION OF PHYSICAL, MEDICAL, FUNCTIONAL, AND EMOTIONAL NEEDS AFTER A NATURAL DISASTER?

Social media data analysis, through content, sentiment, and social network analyses, can help emergency responders plan relief efforts by detecting those in need of medical, functional, and emotional assistance.[11,18,20,27,29,32,37,45-56] The advantage that these methods offer for grouping information shared by social media users can help prioritize areas in need of response and identify the specific problems the affected population is experiencing.[11,20,27,29,30,32,37,40,45-55] Social media posts tagged with geolocations are useful to develop maps that can reduce the response time to events.[21-23,40,56-62] However, challenges remain to be overcome for successful analysis, such as identification of relevant data, developing correct categories for analysis, and inherent limitations after a natural disaster that restrict internet access.[11,47-52]

Recognition of Relevant Social Media Data During Natural Disasters as a Tool to Identify Physical, Medical, Functional, and Emotional Needs

Extracted social media data can be overwhelming for emergency responders to analyze in a fast and effective manner, particularly because so many posts may be irrelevant. Twenty-eight articles analyzed relevant information on social media and how it helped to identify the needs of the affected communities (Table 2). An analysis of Hurricane Matthew and Twitter data identified that only 15.04% of the analyzed posts were related to the disaster, and 4.33% were related to damage during the event.[47] When focusing on social media posting behavior and the area where the event took place, research generally indicated an inverse relationship between distance from hurricanes and storms to areas at risk and relevant tweets to the events.[48,49] However, for earthquakes, an opposite Twitter behavior was observed, with a higher number of social media posts generated in areas where the earthquake was felt with less intensity or not felt at all.[50,51]

Analysis of these data may be further clouded by the fact that, during natural disasters, posting behavior can deviate from baseline behavior, leading to fewer posts originating in geographical areas usually identified with a high volume of social media posts.[52] To help decrease the number of unrelated social media data used in situation analysis, researchers suggested interviewing the responders and creating specific categories to achieve their goals.[11] Including categories of interest for the agencies responding to natural disaster events allowed researchers to reduce Twitter data for the Thailand floods of 2011 to 30% of the original sample size.[11]

Content and Sentiment Analysis as a Tool to Identify Physical, Medical, Functional, and Emotional Needs After Natural Disasters

Content analysis during a disaster of social media posts categorized information as damage reports, injuries, transportation conditions, power outages, evacuations, and concerns for rescue during severe weather events, typhoons, earthquakes, and wildfires.[20,30,37] Social media researchers have developed methodologies to use online data to identify the physical, medical, functional, and emotional needs after a

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disaster by comparing the content of messages shared during the preparedness phase and after the event has taken place.[47,49] During the Nepal earthquake 2015, Twitter data analysis revealed that deaths and killing were the most mentioned categories 15 h after the earthquake.[56] Facebook, YouTube, and Twitter facilitated communication efforts by connecting those in need of help with responders, sharing photos, and sharing ideas to save water during natural disasters.[27,29,53] To identify geographical areas affected by Hurricane Matthew, damage-related tweets served as a better predictor than disaster-related tweets.[47] During Hurricane Sandy in 2012, a positive correlation was observed between the per-capita number of tweets and disaster-inflicted monetary damage calculated from insurance claims after landfall with a Pearson correlation coefficient of 0.6.[49]

In addition to structural and environmental damages, natural disasters also created a change in the emotional state of the individuals expressed through social media.[18,29,37,52,54,55,63] Sentiment analysis methods studied individuals' feelings, emotions, expressions, and trends about a particular topic or natural disaster.[12] For example, sentiment analysis detected negative terms in Twitter content like "death" when focusing on a food category and "crisis" when analyzing medical emergencies.[55] Analyzing the sentiment of social media messages helped to identify the areas in need, but the identification of where response efforts should be deployed first was a challenge. To evaluate the changes in the sentiment of Weibo users after the Ya'an earthquake in 2013, researchers implemented a 4-quadrant distribution to help with faster identification of areas in need to plan and deliver an adequate response, where areas with a high negative sentiment needed to be addressed immediately.[46]

Mapping Tools for Social Media Data to Identify Physical, Medical, Functional, and Emotional Needs After Natural Disasters

Several teams used social media data analysis in innovative approaches by constructing maps for damage identification, actions needed, reports of deaths, earthquake detection, mobility detection, and inundation maps.[21-23,40,56-62] Mapping social media information can help government agencies or emergency responders to attain a spatiotemporal view to offer an efficient response.[57] Maps using social media data included spatial variables that can also help visualize the collected data at different geographical levels.[21-23,40,57-61]

Mapping strategies using social media data have gone beyond identifying a specific location. Researchers have successfully developed mapping systems as a situational awareness and damage reports tool after earthquakes and flooding events.[23] Researchers harnessed social media images to identify affected areas, estimate depth of the flood, and damages during the event.[22,60,61] While investigating Twitter data to build rapid flooding maps during the 2015 South Carolina floods, researchers were able to identify flooded areas previously unknown in official reports.[61] Mapping social media data was helpful for emergency responders to decrease the time needed for a response, such as in the case of the Chennai floods where Twitter data analysis allowed the calculation of faster routes to connect those in need with those offering help.[45]

Despite the advances reached by developing mapping methods using social media data analyses, several challenges were reported by researchers when testing their frameworks. Overestimation of damage in areas affected by earthquakes and low accuracy for earthquake detection for events with a Richter magnitude of 3.5 or lower were reported.[21,23,59] The reviewed articles also presented challenges when analyzing flooding events. When using images from Twitter, Flickr, and other spatial data, depth of inundation was overestimated, and the presence of clouds on images affected the results in overestimation or underestimation of structural damage,[22,60] suggesting the need for methods that overcome the limitations caused by our environment.

DISCUSSION

Summary of Findings

We reviewed the research landscape for the usefulness of social media in public health during the emergency response to natural disasters. Our analysis examined social media analysis methods that can help with information dissemination, early warning dissemination, and identification of needs after a natural disaster. After our screening process (Figure 1), a total of 44 articles were included according to our selection criteria. Multiple studies analyzed information dissemination and the dynamics of the online communication process during the response phase of a natural disaster. Effective disaster response and recovery process were highly dependent on effective communication strategies, timely delivery of warnings, and sharing reports of the situation.[64] Several research articles provided evidence of the use of social media as a broadcasting tool or 1-way communication channel.[8,26,30-33,38,39,41]

A limited number of publications researched misinformation and rumor control on social media during natural disasters.[27,28,32] Rumors and misinformation in social media can spread fast and reach a broad range of users in different locations, directly affecting decision-making and actions taken by citizens and responders.[27] If emergency management agencies can detect social media messages with false or unverified information, the dissemination of these posts can be controlled by sharing timely updates related to the event and the progress of the response.[27,65] However, identifying this information would require a highly active presence and engagement of emergency management agencies across all social media platforms, time to verify the information, and open and honest communication.[28,29,43] Several articles found that, while experiencing an event, such as a natural disaster, individuals turn their attention to official sources; given the attributes of social

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media, posts carrying the correct information can reach a high number of users and can help decrease risk or feelings of despair.[37,41,46,54,55] Strategies to increase the number of followers must be implemented, targeting users' demographic profiles.[32,66]

An important finding of our literature review is the need to use social media as a 2-way communication tool and not just for disseminating information. Social media sites offer a platform for commenting on posts that help develop interactions between the affected population and emergency management agencies. In return, these organizations can gain information for situational awareness and policy development during a disaster situation.[27,28,53] Our literature review presents how social media has a place during the response phase of a natural disaster.

Strengths and Limitations

Our review made use of 3 different key words combination on 3 different databases that publish health-related content and digital technology research. Our selection of "social media" as a key word allowed us to collect information from multiple platforms and not just the specific social media sites with global exposure. Our search was limited to only peer-reviewed research articles published in English or Spanish, excluding other types of publications. Therefore, it is possible some research articles were missed and not included in the literature review.

Strengths from the reviewed literature include the analysis of large samples of social media data, analysis from multiple natural disasters, and numerous locations. Several research articles used SNA to determine the relationship between the social media account and those who follow them.[8,10,25,28-32,34-38] Various authors included retweets in their investigation or did a separate analysis of retweets for their research, which differs from previously published literature.[5,8,10,25-28,30-32,35,37,38,41,49,50] One of the limitations of the broader landscape of the literature, as identified in this review is the focus on Twitter data in the majority of the articles. It is essential to consider the demographic factors of social media users in the geographical area of interest. Social media use can differ by region and preferences of the population, limiting the retrieval of the desired information.[51] Thus, the results obtained using social data might not represent the general population affected by the event. Also, results obtained by the researchers are specific to the event of interest and the geographical region analyzed.[29,38]

The majority of the reviewed articles reported retrospective analyses of the data. Only 1 publication tested their proposed frameworks in a response practice training exercise for a natural disaster.[40] Another limitation identified is the restricted number of geolocated social media posts. Due to the privacy settings of a majority of social media users, their geolocated data cannot be retrieved.[67] To overcome this limitation, researchers opted for inferring the location by matching terms that appeared in their self-reported social media profiles to geocoordinates, but this methodology introduces uncertainty to the analysis.[56]

Social media was identified as a broadcasting tool or a 1-way communication channel by several authors.[8,26,30-33,38,39,41] Owners of social media profiles can take advantage of the comments or mention features of social media platforms to engage with the population who experienced the disaster event and offer advice and help. However, opening a 2-way communication channel will require active use from profile owners to constantly verify posts or messages, which can require the recruitment of a team member designated for social media work.

Finally, the use of key words to extract social media data can limit the data collection process if the term used is different from the one used by the local population.[8]

Public Health Implications

Social media helps with timely dissemination of information; individual users and official media accounts are among those with the highest reach in social media platforms, such as Twitter and Facebook.[68] These identified characteristics present an opportunity for emergency management agencies. Individuals look to share information from official sources, and by maintaining a highly active account, warnings and official information can be shared by the users. Social media sites offer the option of sharing videos or photos of the areas affected by the natural disaster allowing those witnessing the event from other countries to gather information, organize help, and volunteer efforts. Official emergency management agencies can also take advantage of this feature. Several research studies express the need for opening a 2-way dialogue between social media users and official agencies to identify specific needs of those affected by the disaster.[10,20,25-29,34-36,53]

A benefit public health officials can acquire using social media data analysis is the retrieval of up-to-date information about airport viability.[39] The same approach can be implemented for hospitals and government offices, providing a tool for public health surveillance. Similarly, unplanned school closures during natural disasters can be identified by monitoring social media platform Twitter.[69] Also, the development of websites and smartphone applications can offer a faster response to affected areas. These applications have the potential to complement current community assessment tools for an early start in the planning process.

CONCLUSIONS AND FUTURE RESEARCH

Social media can be used as a tool during emergency responses to a natural disaster. It can be implemented in communication strategies for information and emergency warnings dissemination and

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to start a 2-way dialogue between responders and those affected by the emergency event. Social media analysis can serve as a tool to recognize emotions of those affected by disasters, their needs, and damage caused by the event. Social media data have also been used for event detection, mapping, and volunteer organization. Our findings present how social media content depends on the intensity of the event and the studied area. Due to the limited resources after a natural disaster, those who were most affected by the event might not have the resources to share social media content. However, government emergency management agencies should maintain active accounts on popular social media platforms to ensure that every user is reached. Furthermore, accessibility to social media data is limited by both privacy concerns and financial costs, resulting in limited academic research and the validation of methods to multiple platforms that can help the response to natural disasters. Future research should focus on social media use as a nontraditional form of public health surveillance during the response phase of a natural disaster, for its impact on disease and community resources.

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Supplementary material

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