Social media and disasters: a functional framework for social media use in disaster planning, response, and research

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A comprehensive review of online, official, and scientific literature was carried out in 2012–13 to develop a framework of disaster social media. This framework can be used to facilitate the creation of disaster social media tools, the formulation of disaster social media implementation processes, and the scientific study of disaster social media effects. Disaster social media users in the framework include communities, government, individuals, organisations, and media outlets. Fifteen distinct disaster social media uses were identified, ranging from preparing and receiving disaster preparedness information and warnings and signalling and detecting disasters prior to an event to (re)connecting community members following a disaster. The framework illustrates that a variety of entities may utilise and produce disaster social media content. Consequently, disaster social media use can be conceptualised as occurring at a number of levels, even within the same disaster. Suggestions are provided on how the proposed framework can inform future disaster social media development and research.

Keywords: communication, crisis, disaster, social media, technology

Introduction

Communication is a core component of disaster planning, response, and recovery. Effective disaster communication may prevent a disaster or lessen its impact, whereas ineffective disaster communication may cause a disaster or make its effects worse. Rodriguez et al. (2007, p. 479) note that disasters often are the 'result of a crisis in the communication process or a result of a communication breakdown'. In addition, disasters frequently cause damage to the communication and information infrastructure, leading to reduced availability and a decreased flow of information (Shklovski et al., 2010). This diminished communication capacity occurs at a time when uncertainty and threat are great, producing a high demand for information. Consequently, developing effective disaster communication processes and systems should be a priority for governments, organisations, communities, and citizens. Emerging and evolving communication technologies, such as social media, offer the possibility of improved disaster communication, as these technologies have the potential for increased information capacity, dependability, and interactivity (Jaeger et al., 2007). However, while

the utility of social media relative to disasters is intuitively appealing, many disaster social media 'applications remain speculative, while others remain in their infancy' (Lindsay, 2011, p. 2). Furthermore, nascent are both governmental and organisational efforts to formulate protocols for integrating social media into existing disaster systems and scientific attempts to understand the effects of disaster social media use (Bruns et al., 2012).

To facilitate the development of disaster social media tools, the formulation of disaster social media implementation processes, and the scientific study of disaster social media effects, a comprehensive framework of who uses disaster social media and how disaster social media is employed is needed. As a first step in developing such a framework, this study systematically reviews the disaster social media literature to identify and categorise (i) disaster social media users and (ii) disaster social media functions. The resulting disaster social media framework can be used to inform the implementation and evaluation of future disaster social media efforts and to guide disaster social media research. Moreover, as social media technologies evolve, the framework can be updated and adjusted to reflect the changing technology landscape. To begin, the paper briefly reviews the concepts of disasters, disaster communication, social media, and disaster social media.

Key concepts

Disasters

While a variety of disaster definitions exist (Perry, 2007), this research uses the definition of McFarlane and Norris (2006, p. 4) that a disaster is 'a potentially traumatic event that is collectively experienced, has an acute onset, and is time-delimited'. Disasters may have natural (such as an earthquake or a hurricane), technological (such as an oil spill), or human (such as terrorism) causes, and may produce 'physical, social, psychosocial, sociodemographic, socioeconomic, and political consequences' (Houston, Pfefferbaum, and Rosenholtz, 2012, p. 607). Normally, disasters are conceptualised in phases, and can be understood as including a pre-event, event, and post-event phase (Houston, 2012).

Disaster communication

Historically, much of the academic literature addressing disaster communication has involved crisis or risk communication (Houston, Pfefferbaum, and Rosenholtz, 2012). The study of crisis communication is usually located in the public relations or organisational communication literatures and is focused primarily on examining strategies that can protect an organisation's image during a crisis (Reynolds and Seeger, 2005; Seeger, 2006), whereas the study of risk communication generally is focused on understanding how to influence individuals' risk knowledge, attitudes, and behaviour (Witte, 1995).

Crisis and risk communication are both relevant to disaster communication. For example, the study of how to design and deliver disaster warnings is an important component of risk communication with significant relevance to disaster communication (Rodriguez et al., 2007). However, disaster communication also centres on additional objectives beyond those found in the crisis and risk communication literatures. For instance, recent disaster communication approaches, such as the Crisis and Emergency Risk Communication (CERC) model (Reynolds and Seeger, 2012) and the Disaster Communication Intervention Framework (DCIF) (Houston, 2012), target outcomes beyond protecting an organisational image or influencing understanding of risk. The CERC model proposes using disaster communication to 'prevent further illness, injury, or death; restore or maintain calm; and engender confidence in the operational response' (Reynolds, 2006, p. 249), whereas the DCIF concentrates on outcomes such as: improving individual and community disaster preparedness; increasing individual and community resilience; decreasing disaster-related distress and maladaptive behaviour; promoting wellness, coping, and recovery; helping a community to make sense of what happened; and (re)connecting the community (Houston, 2012).

Disaster communication typically has been thought of as occurring principally via the mass media (Rodriguez et al., 2007). Mass mediated disaster communication generally consists of disaster warning messages and of mass media news coverage of disasters. Disaster warnings usually originate from official government agencies such as the National Weather Service (NWS) and are disseminated through mass broadcast channels (such as radio and television). Among the general public of the United States, news coverage of disasters commonly garners more attention than any other issue (Robinson, 2007; Pew Research Center, 2010). Rodriguez et al. (2007, p. 482) contend that mass media coverage of disasters 'significantly influences or shapes how the population and the government views, perceives, and responds to hazards and disasters'. Hence, mass mediated disaster communication may be quite powerful in influencing individual disaster knowledge, attitudes, and behaviour. At the same time, mass mediated coverage of disasters is limited in that normally it involves messages created by a single source and disseminated to large audiences, with little opportunity for audience response and participation. However, the evolution of new communication technologies, such as social media technologies, offers more opportunity for two-way mediated communication (Fraustino, Liu, and Jin, 2012). As a result, the promise of richer disaster communication via social media has captured the attention of disaster communicators (see, for example, Reynolds and Seeger, 2012).

Social media

Social media (which may also be referred to as social networking or Web 2.0) is a broad term for a variety of web-based platforms and services that allow users to develop public or semi-public profiles and/or content, and to connect with other users' profiles and/or content (Boyd and Ellison, 2008; Blank and Reisdorf, 2012). Social media typically can be accessed by a variety of computing devices, including

desktop or laptop computers, smartphones, and tablets; and the number of individuals accessing social media via mobile computing devices (such as smartphones and tablets) is increasing (Brenner and Smith, 2013; Constine, 2013). Blank and Reisdorf (2012) argue that the value of these new social media is derived from emergent network effects, in which large numbers of users find a particular platform or service useful and so a value emerges from the entity that would not have been realised otherwise. Examples of social media include blogs and micro-blogs (such as Blogger, Twitter, WordPress), discussion forums (such as Quora, Reddit), digital content sharing platforms (such as Flickr, Instagram, Pinterest, YouTube), social gaming sites (such as Gree, Mobage, Zynga), and social networking sites (such as Facebook, Google+, LinkedIn, Mixi, Orkut) (Fraustino, Liu, and Jin, 2012). Some social media platforms and services are used by global audiences (such as Facebook, Twitter), whereas other social media are mostly popular in specific countries or regions (such as Mixi, Orkut). Furthermore, while an individual may be using a global social media platform or service (such as Facebook), he/she may be connected to local individuals and organisations.

Many social media platforms and services offer more dynamic content, images, games, audio, and video as compared to previous iterations of internet websites and applications, resulting in a richer user experience (O'Reilly, 2005). Specific social media platforms and services vary both in their focus (such as digital sharing of specific content forms, social gaming) and in their optimisation for different computing devices (such as desktop versus mobile computing devices), yet as a broad category, social media ultimately are platforms and services that offer users the opportunity to publish content, to connect with other people, and to engage in conversation. Social media may be used to connect with new people or to maintain existing social ties (Haythornthwaite, 2005). Social media advocates have posited that these new technologies may fundamentally affect how individuals learn, interact, and organise (Palfrey and Gasser, 2008; Shirky, 2008).

Disaster social media

Social media has spread to many domains, including the realm of disasters (Lindsay, 2011). Disaster planners, responders, and researchers frequently exhibit optimism regarding social media's potential to facilitate improved disaster communication and operations (see, for example, Lindsay, 2011; Fraustino, Liu, and Jin, 2012; Reynolds and Seeger, 2012; Williams, Williams, and Burton, 2012). Much of this optimism is based on social media characteristics that are said to provide advantages over traditional media (such as newspapers, radio, television) for disaster communication. For instance, Jaeger et al. (2007) note that compared to traditional media, web-based social media technologies are characterised by greater capacity, dependability, and interactivity, each of which may be advantageous for disaster communication. In addition, Mills et al. (2009, pp. 12–13) assert that an ideal emergency communication system is a low-cost, easy-to-use, scalable, mobile, reliable, and fast network that provides capacity for one-to-many communication, includes useful information, and has GIS (geographic information systems) capacity and visualisation tools.

Social media normally have many of these characteristics. Finally, in the context of disaster communication, Keim and Noji (2011, p. 52) describe the advantages of social media in comparison to traditional media, notably in terms of information flow, information control, adaptability, relevance for local residents, intelligence, empowerment, dependency on the power grid, cost, accessibility, and timeliness of information. The use of social media via mobile computing devices such as smartphones and tablets may be particularly helpful during a disaster that occurs without warning or in a remote location. This is because these devices may be used by citizens who are able to document and share information about events as they unfold, even in the absence of professional news organisations and journalists (Meikle and Redden, 2011).

Owing to social media's apparent capacity to improve disaster communication, a number of organisational, governmental, and scientific reports have examined different aspects and applications of disaster social media (see, for example, Lindsay, 2011; Fraustino, Liu, and Jin, 2012). What is currently missing from the disaster social media literature, though, is a comprehensive framework that outlines who uses disaster social media and how social media has been (or might be) employed in disaster communication. Such a framework would make a significant contribution to the literature as it could be used to organise existing and future research on disaster social media, to guide the development and implementation of future social media applications, to recognise future evolutions in disaster social media use, and to identify gaps in existing disaster social media knowledge. Such a framework is proposed here.

This study's functional framework for disaster social media is based on a uses and gratifications approach to understanding media. Uses and gratifications is not the study of what effects media have on users, but of how individuals use media (Katz, 1959). Thus it is a functional approach to media use. Inherent in a uses and gratifications exploration of media use is the idea that individuals use media to address different needs (Katz, Blumler, and Gurevich, 1974). So, for instance, individuals may watch television to obtain information, to pass time, or to experience an emotion. Knowing how individuals use media and for what purpose is an essential component in comprehending the (evolving) media landscape.

As a conceptual approach to understanding media use, the uses and gratifications approach was developed between the 1940s and the 1970s during a period dominated by traditional mass media (such as newspapers, radio, and television). Mass media typically involve one-way communication wherein individual media sources communicate information to a large numbers of users. As a result, early uses and gratification research focused on how individuals (the users) used mass media. However, with the advent of social media, the notion of who or what constitutes a *user* is less obvious. This is because social media's capacity for two-way, synchronous communication means that both traditional media content creators (such as news organisations, corporations) and traditional users (such as individuals) can *create* and *consume* content. For example, in the social media environment, a news organisation may be the creator of content at one moment (such as posting a news story online), and then that

organisation may be consuming social media content from individuals at the next moment (such as monitoring social media to see how citizens are reacting to a specific event). Once disaster social media users are understood, one can examine how disaster social media is used. Overall then, a framework of disaster social media use is developed by (i) determining who are social media *users*, and (ii) exploring how these users *use* disaster social media.

Methodology

To develop a disaster social media framework of users and uses, we began by conducting a comprehensive literature review. Adapting the disaster literature review process described by Rodriguez et al. (2007, p. xiv), we searched the online literature (such as blog posts, organisational websites), the official literature (such as government and disaster organisation reports), and the scientific literature (such as books, journal articles). Each of the literature searches employed the following terms: disaster, disasters, crisis, catastrophe *and* social media, social network, social networking, Web 2.0, internet, online. We searched the online literature using Google Search in order to identify reports of emergent disaster social media use that had likely not yet appeared in the official or scientific literature. The official literature was searched using Google Search and Google Scholar. The scientific literature was searched using Google Scholar, and the PsycINFO, MEDLINE, Communication and Mass Media Complete, and Academic Search Complete databases. The reference sections of sources pinpointed in our review were also searched for additional literature.

After the initial search of the literature, all sources (articles, blog posts, reports) that, based on the title, appeared relevant to our topic of interest were examined further. Ultimately, we retained sources that (i) clearly addressed disasters and (ii) involved social media. Our operationalisation of disasters included natural disasters (such as hurricanes, tornadoes) and man-made disasters (such as mass shootings, terrorist attacks), but did not include organisational crises that were not disaster-related (such as product recalls), political crises (such as the Arab Spring), or ongoing conflicts (such as civil wars). Our operationalisation of social media was broad and we included any potentially web-based technology that allowed for the participation or interaction of multiple users (such as websites that allow for user comments, blogs, and online GIS).

Once all sources were identified, we worked collaboratively using a qualitative grounded theory approach (Strauss and Corbin, 1998) to develop categories of disaster social media users and uses based on a review of all sources. We employed inductive coding so that coding themes were not known prior to analysis, but instead emerged through a constant comparative method in which coders reviewed all sources and then worked together to distinguish categories. Once categories were identified, relevant portions of sources were placed into appropriate categories to explicate and illustrate each category in the following section.

Results and discussion

Disaster social media users

We began by examining the disaster social media literature to ascertain possible users of disaster social media. Our review pinpointed the following users: (i) individuals, (ii) communities, (iii) organisations, (iv) governments, and (v) news media. Although we refer to these entities as *users* in the framework, all of the identified social media users were also found to function as disaster social media content producers in our review, illustrating the two-way communication nature of social media.

Regarding the users detected in our literature evaluation, individuals included people in general, such as private citizens who were not using disaster social media as an agent of another entity (such as a government or an organisation). When a disaster occurs, individuals who use disaster social media may be located within or without the disaster-affected area. Communities included groups of people connected by geographic areas such as neighbourhoods or towns, as well as groups of people 'who share expertise, values, norms, interest, and experiences' (Wyche et al., 2011, p. 18) and who may or may not also share a common geographic area. Social media may facilitate connections within both types of communities, as communication technologies can function as community resources (Shklovski, Palen, and Sutton, 2010). Organisations are structured groups of people that are responding to, affected by, or external to the disaster. For instance, organisations using disaster social media might include a disaster response entity such as the Salvation Army, a business impacted by the disaster, or a volunteer association not in the disaster-affected area that is collecting donations for the community experiencing a disaster.

Governments include those at the federal, state, and local level and governmental agencies. Examples of government disaster social media users include local departments of emergency management, state departments of public safety, the US Federal Emergency Management Agency (FEMA), and the NWS.

Media include organisations, such as those that are large or small, and those that are traditional or new in nature. Examples are a local community blog, a state newspaper, national television broadcast networks (such as ABC News), and international news organisations (such as Reuters).

Disaster social media uses

Next we examined the disaster social media literature to develop a comprehensive framework of disaster social media uses. As mentioned, we conceptualised disaster social media use across three disaster phases: pre-event, event, and post-event. Table 1 shows the disaster social media uses we identified through the literature review and the disaster phase(s) to which each use corresponds. Since the disaster social media users identified in the previous section can function as users and producers of disaster social media content, our disaster social media uses were conceptualised as two-way communication activities, specifying both the user and the consumer function of activity. Each disaster social media use is described below.

Table 1. Functions of disaster social media

Disaster social media use	Disaster phase
Provide and receive disaster preparedness information	Pre-event
Provide and receive disaster warnings	Pre-event
Signal and detect disasters	Pre-event → Event
Send and receive requests for help or assistance	Event
Inform others about one's own condition and location and learn about a disaster-affected individual's condition and location	Event
Document and learn what is happening in the disaster	Event → Post-event
Deliver and consume news coverage of the disaster	Event → Post-event
Provide and receive disaster response information; identify and list ways to assist in the disaster response	Event → Post-event
Raise and develop awareness of an event; donate and receive donations; identify and list ways to help or volunteer	Event → Post-event
Provide and receive disaster mental/behavioural health support	Event → Post-event
Express emotions, concerns, well-wishes; memorialise victims	Event → Post-event
Provide and receive information about (and discuss) disaster response, recovery, and rebuilding; tell and hear stories about the disaster	Event → Post-event
Discuss socio-political and scientific causes and implications of and responsibility for events	Post-event
(Re)connect community members	Post-event
Implement traditional crisis communication activities	Pre-event → Post-event

Provide and receive disaster preparedness information

An informed and prepared populace may be more resilient in the face of a disaster (Norris et al., 2008; Houston, 2012), thus efforts by individuals and organisations to learn how to prepare for a disaster and by organisations and government to disseminate disaster preparedness content can benefit people and communities. Disaster social media can assist this process by connecting individuals and organisations to disaster preparedness information ahead of an event (Vieweg et al., 2010; Lindsay, 2011; Rive et al., 2012). Furthermore, instead of reaching only individuals or organisations who actively seek out disaster preparedness information, social media offers the potential for users to connect to disaster information unintentionally. For instance, a user may encounter disaster preparedness information via a posting from an account they follow on Facebook or Twitter (one that is not specifically disaster-focused, but has still posted or tweeted the information), thereby expanding the effect of disaster preparedness information beyond those who are motivated to look for the content. A possible additional benefit of such serendipitous information-based connections is that the connections, if reoccurring or maintained, may also lead to improved social capital and social connections in a community, which is likely to improve overall levels of community resilience (Norris et al., 2008).

Provide and receive disaster warnings

Also during the pre-event phase, disaster social media can be used to provide and receive disasters warnings (Samarajiva, 2005; White et al., 2009; Chavez, Repas, and Stefaniak, 2010; Vieweg et al., 2010; Acar and Muraki, 2011; Lindsay, 2011; Rive et al., 2012). Disaster organisations (such as FEMA or the NWS) can disseminate disaster warnings via social media sites such as Facebook and Twitter, meaning that anyone following or connected to these accounts will receive the warnings. In addition, even if a user is not connected to the NWS account, for example, he/she may see the NWS warning as a result of it being reposted or retweeted by someone else within the individual's social network. In this way warnings can propagate through online social networks, providing more value as they are shared broadly. Furthermore, social media offers the potential for disaster warnings to be distributed to anyone with a specific account or device in a geographic area. For instance, disaster warnings could be disseminated from mobile telephone towers to all mobile telephones and smartphones in a specific area (Samarajiva, 2005). Such an automated warning system would mean that users do not have to sign up for or choose to receive these updates, but instead would get the messages simply due to possessing the appropriate device and being in the danger zone.

Signal and detect disasters

Social media can be used to signal and detect disasters (Samarajiva, 2005; Jaeger et al., 2007; Huang, Chan, and Hyder, 2010; Lindsay, 2011). Disasters may be signalled through users' posts to social media sites such as Facebook or Twitter. During the earthquake in the US state of Virginia in 2011, for example, some individuals in the eastern US reported reading about the event on Twitter before feeling the earthquake in their location (Ford, 2011; Kang, 2011). Data visualisations of the movement of the Virginia earthquake's seismic waves and earthquake-related tweets showed tweets moving across the US faster than the earthquake (Honan, 2011; Lotan, 2011). To capitalise on user reports of earthquakes, the U.S. Geological Survey has developed a 'Did you feel it?' web application[2] that allows users to provide updates on any earthquakes they experience (or feel). These individual reports are collated and then displayed on a map available on the website.

It is also possible that disaster social media listening operations can be developed to monitor social media streams and then detect disasters and issue alerts based on recognition of social media content that, in terms of language or traffic patterns, indicates a disaster (Warner, 2012). Furthermore, as technology continues to develop, social media may be used to provide more passive (vis-à-vis the effort required by users to report the disaster) disaster detection. Smartphones and other mobile devices may eventually be capable of sensing seismic waves to detect earthquakes or of monitoring air particulates to reveal dangerous biological agents. Once a disaster or danger is perceived, these devices could automatically connect with cellular or internet networks to report to a monitoring centre, potentially activating an alert and response.

Send and receive requests for help or assistance

Social media is reported to be generally more reliable in disaster situations, hence requests for help post disaster may be communicated via social media (Acar and Muraki, 2011; Lindsay, 2011; Baer, 2012; Taylor et al., 2012; Warner, 2012; Williams, Williams, and Burton, 2012). For instance, in a study of Twitter use during the earthquake and tsunami off the Pacific coast of Tōhoku, Japan, in 2011, Acar and Muraki (2011) identified several tweets that were direct requests for help. For example, one read: 'We're on the 7th floor of Inawashiro Hospital, but because of the risen [*sic*] sea level, we're stuck. Help us!' (Acar and Muraki, 2011, p. 397). A social media listening tool, such as the one developed by the ARC (Warner, 2012), potentially could spot such tweets and dispatch disaster responders to assist individuals in need. Community 999[3] centres also could monitor social media networks to identify emergency requests for help. In a 2012 survey of US adults, a majority of respondents indicated that they thought that local and national emergency response organisations should monitor their websites and social media sites so that they could respond to any requests for help (ARC, 2012).

Inform others about one's own condition and location and learn about a disaster-affected individual's condition and location

During and immediately following a disaster, people will want to know if family and friends in the affected area are safe. What is more, if the level of destruction is great, individuals often will need a place to check in, to let others know their condition, and to establish connections with others. Social media can aid these processes (Procopio and Procopio, 2007; Hughes et al., 2008; White et al., 2009; Acar and Muraki, 2011; Lindsay, 2011; Austin, Liu, and Jin, 2012; Baer, 2012; Bunce, Partridge, and Davis, 2012; Williams, Williams, and Burton, 2012). After Hurricane Katrina, for instance, internet sites of 'safe lists' were developed that included the names of people who reported that they were safe after the storm (Shklovski et al., 2010, p. 9). Furthermore, in the wake of the mass shooting on the campus of Virginia Polytechnic Institute and State University (Virginia Tech) in the US on 16 April 2007, students used text and instant messaging to let others know that they were safe and to check on the safety of friends (Palen, 2008; Palen et al., 2009). Finally, during the event phase of a major flood in Australia in 2011, residents reported using disaster social media to seek 'assurance' that family and friends (and property) were safe (Bunce, Partridge, and Davis, 2012, p. 42). The ARC currently operates a 'Safe and Well' website dedicated to registering individuals as safe following any disaster.[4]

Document and learn what is happening in the disaster

Given the uncertainty and the threats that typically result from a disaster, information on what has happened and is occurring is needed by individuals within and without a disaster area (Rodriquez et al., 2007). Disaster social media provides a potentially useful medium for individuals and organisations to document the impact of a

disaster and to find out what is going on (White et al., 2009; Huang, Chan, and Hyder, 2010; Vieweg et al., 2010; Acar and Muraki, 2011; Keim and Noji, 2011; Lindsay, 2011; Bunce, Partridge, and Davis, 2012; Bruns et al., 2012; Murthy and Longwell, 2012; Rive et al., 2012; Taylor et al., 2012; Williams, Williams, and Burton, 2012).

In disaster conditions, social media may prove more dependable than traditional forms of media. Immediately following Hurricane Katrina, for instance, text messaging was frequently the only way for individuals affected by the storm to stay in touch with each other and to find out what was transpiring (Shklovksi et al., 2010). In addition to dependability, disaster social media may prove to be a quicker mechanism through which to receive accurate disaster information than traditional disaster media (Bunce, Partridge, and Davis, 2012). Microblog social media services, such as Twitter, may be particularly useful for documenting information on a disaster. For example, a study of the 2010 earthquake in Haiti found that there were more social media posts about the event on Twitter than on Facebook, another social media site (Muralidharan et al., 2011).

Increasingly, the post–disaster landscape is marked by a 'decentralized, highly distributed information production' as compared to previous generations (Palen et al., 2009, p. 476), in which individuals or groups using various social media platforms have emerged as 'information brokers' or hubs for a particular disaster (Palen, 2008, p. 78). These information brokers normally collect, collate, and link to information on the event from a variety of sources. Other social media users may contribute to these hubs by posting comments or directing tweets or other posts at the entity assembling the information. Such a system allows the information on an event to be collected from a variety of users in different locations, allowing the production of content to be distributed (and thus the information network may be more resilient). The curation of user-provided disaster images on sites such as Flickr and Instagram is one type of content that often is collected collaboratively post disaster (Liu et al., 2008).

Disaster reporting and curation by unknown individuals and organisations may raise concerns about the accuracy of information, the potential for rumours, the maliciousness of use (such as scams conducted by social media), and the protection of privacy (Huang, Chan, and Hyder, 2010; Acar and Muraki, 2011; Lindsay, 2011; Taylor et al., 2012). Intuitively, one might question the accuracy of non-centralised and unofficial information. However, after the Virginia Tech shooting, Palen et al. (2009, p. 476) found that the collective 'problem-solving efforts included fact-checking and source identification, which contrasts with rumor-mongering'. Another example of social media's capacity to correct erroneous information occurred during the floods in Queensland, Australia, in 2010–11, when state police posted a series of tweets labelled '#Mythbuster' that were intended to address any flood rumours or misinformation circulating on Twitter (Bruns et al., 2012).

Online geospatial technologies, such as GIS, provide a capacity for collaborative or crowd-sourced mapping that can be used to aid a disaster response and provide a visual understanding of what is happening (Laituri and Kodrich, 2008; Goolsby, 2010; Zook et al., 2010; Keim and Noji, 2011; Kawasaki, Berman, and Guan, 2012). Many

users can utilise online geospatial technologies simultaneously to report on local conditions (such as the amount of damage or the location of survivors) and connect those reports to exact geographic locations. Such crowd-sourced maps can improve the situational awareness of disaster management and responders by supplying details about conditions throughout the affected area (Vieweg et al., 2010; Lindsay, 2011, p. 4; Rive et al., 2012). Crowd-sourced maps can also aid individuals outside the disaster zone. For instance, maps were used by individuals who evacuated as a result of Hurricane Katrina to determine flood levels in specific neighbourhoods (Shklovski et al., 2010). This information helped evacuees to make decisions about when and if to return home.

Maps can also be developed using existing social media content. The American Red Cross (ARC), for example, has developed a social media monitoring system that produces a geographic 'heat map' of disaster social media activity (Warner, 2012), which can be used to inform disaster response and to update social media users about what is occurring in a disaster area. The ARC approach is an example of 'infoveillance', which is the process of monitoring and analysing social media data to understand the nature of a disaster (Chew and Eysenbach, 2010).

Deliver and consume news coverage of the disaster

Delivering and consuming news coverage of a disaster is very similar to the previous disaster social media function (document and learn what is happening), as both are focused on recording and finding out what is going on in the aftermath. However, the news function concentrates specifically on coverage of the event from a news or journalism perspective. There may be significant overlap between citizen, organisation, and journalist reports of a disaster on social media. Ultimately, though, disaster social media is a core component of traditional news coverage of modern disasters (Kodrich and Laituri, 2005, 2005–06; Muralidharan, Dillistone, and Shin, 2011; Murthy and Longwell, 2012). In addition, social media may act 'as a conduit; orienting people to official sources of information and amplifying these messages to a broader audience' (Taylor et al., 2012, p. 24). Social media, therefore, may both inform and broaden the reach of traditional news coverage of a disaster.

Provide and receive disaster response information; identify and list ways to assist in the disaster response

Post disaster, individuals and organisations may want to know what is happening with the disaster response and determine how they might help. Social media can assist with this process (Jaeger et al., 2007; Hughes et al., 2008; White et al., 2009; Keim and Noji, 2011; Baer, 2012; Taylor et al., 2012; Wei, Bu, and Liang, 2012; Williams, Williams, and Burton, 2012). Social media updates can quickly and consistently provide a stream of coordinated and distributed information about what is taking place and what is needed relative to a disaster. Community-oriented disaster social media sites may be particularly useful in collating response information and details (Williams, Williams, and Burton, 2012)

Raise and develop awareness of an event; donate and receive donations; identify and list ways to help or volunteer

Disaster social media can be used to raise awareness of the impact of a disaster on individuals and communities, to facilitate donations to help those affected by a disaster, and to provide opportunities for individuals to list and find ways to help with disaster response and recovery (Kodrich and Laituri, 2005, 2005–06; Torrey et al., 2006; Jaeger et al., 2007; Huang, Chan, and Hyder, 2010; Smith, 2010; Zook et al., 2010; Keim and Noji, 2011; Lindsay, 2011; Muralidharan et al., 2011; Baer, 2012; Bunce, Partridge, and Davis, 2012; Lobb, Mock, and Hutchinson, 2012; Seo et al., 2012; Taylor et al., 2012; Williams, Williams, and Burton, 2012). For some events, raising awareness of the scope of the impact and the destruction resulting from a disaster is necessary to motivate individuals to donate or volunteer. For other (major) events the willingness of individuals to donate and volunteer may be great, so that little additional awareness raising is necessary. Bruns et al. (2012) note that volunteering and fundraising messages related to the Queensland Floods of 2010–11 appeared on Twitter during the latter days of the crisis.

In terms of using social media to raise donations, the ARC established a text donation system after the Haiti earthquake of 2010, in which individuals were asked to text 'Haiti' to a specific number and then a USD 10 donation was charged to the individual's mobile telephone bill. This text-based donation campaign raised more than USD 32 million dollars (Warner, 2012). Research also found that more frequent social media messages about the Haiti earthquake were associated with increased financial donations to the response (Lobb, Mock, and Hutchinson, 2012).

In terms of volunteering, a study on the Sichuan earthquake in western China in 2008 revealed that more involvement with internet content about the disaster was indirectly related to greater willingness to help the victims (Seo et al., 2012). Thus exposure and attention to disaster social media content may motivate individuals to become more involved in helping those affected. Moreover, one benefit of social media is that people do not necessarily have to be in the disaster area to help (Zook et al., 2010). Following a disaster, users can assist the response by curating available information on the event and then contributing to disaster maps, by collating online disaster information, and by raising awareness of the situation via their online social networks.

Provide and receive disaster mental/behavioural health support

An emergent use of disaster social media is to provide and receive disaster mental/behavioural health support (Jain, 2013). For instance, disaster social media may be a mechanism through which individuals experiencing a disaster are connected with mental/behavioural health services or information (Houston, 2012). More generally, social media may connect disaster survivors to other individuals who experienced the incident, to friends and family, and to individuals external to the disaster who are concerned about what occurred, thereby providing a resource for social support (Vicary and Fraley, 2010). Individuals experiencing a crisis may prefer more micro

media (such as targeted websites, mobile telephones, or smartphones) to meet their emotional and cognitive needs than traditional mass media (Lev-On, 2012). Social media can even function as a mechanism to provide 'digital hugs' to affected individuals (Baer, 2012, para. 5).

In the wake of the mass shootings at Virginia Tech (16 April 2007) and Northern Illinois University (14 February 2008), many students reported creating online groups focused on the events as a method to cope with their grief (Vicary and Fraley, 2012). Students who posted to online groups or Facebook profiles related to the tragedies reported feeling better as a result of these activities (Vicary and Fraley, 2012). Furthermore, following a cyclone in Australia and New Zealand in 2011, survey participants who used disaster social media 'reported feeling a sense of connectedness and usefulness, felt supported by others and felt encouraged by the help and support being given to people' (Taylor et al., 2012, p. 25). The use of disaster social media, therefore, may facilitate attitudes and feelings that may be associated with improved mental/behavioural health.

Express emotions, concerns, well-wishes; memorialise victims

Social media can provide an opportunity for users to express their emotions about an event, to convey that they are concerned about those affected by an event, and to mourn and memorialise anyone killed in an event (Procopio and Procopio, 2007; Hughes et al., 2008; White et al., 2009; Smith, 2010; Hjorth and Kim, 2011; Taylor et al., 2012). Following the incidents at Virginia Tech and Northern Illinois University, students reported contributing to memorial websites and posting messages on the Facebook profiles of students who lost their lives (Vicary and Fraley, 2010). Since social media sites often allow for individuals to create their own public profiles, these online profiles may be where others come to mourn and memorialise the victims. Such expressions of mourning may even come from users located far from the disaster site. For example, an individual in Africa could post a memorial message on the social media profile of a person killed in a tornado in the US. Disaster memorials may also be constructed using online virtual reality platforms such as Second Life (Liu et al., 2008).

Provide and receive information about (and discuss) disaster response, recovery, and rebuilding; tell and hear stories about the disaster

As the event phase of the disaster recedes to the post-event time frame, social media may allow users to continue to stay engaged with efforts related to the disaster and to exchange stories of personal involvement (Procopio and Procopio, 2007; Chen et al., 2012). While traditional mass media news coverage of disasters generally is sustained for shorter periods than for other issues (Houston, Pfefferbaum, and Rosenholtz, 2012), coverage of a disaster may last longer on some social media sites, such as Facebook (Lobb, Mock, and Hutchinson, 2012).

Furthermore, in a study of the Loma Prieta earthquake in California in 1989, Pennebaker and Harber (1993) identified a social stage model of disaster coping based

on interpersonal communication. In this model, an emergency phase that involved individuals talking openly about the disaster with others began immediately after the event and lasted for a few weeks. This was followed, though, by an inhibition phase, in which individuals still wanted to talk about the event, but did not want to hear about it from others. At this point, talking about the event was constrained in the community and a corresponding spike in mental health and functioning problems related to the disaster materialised. Perhaps online social media can provide users with an opportunity to discuss a disaster during this inhibition phase. By expanding the social network beyond just those located in geographical proximity to the event and capable of in-person interpersonal communication, disaster social media may facilitate talking during this time, which could be beneficial to affected individuals. Finally, social media may offer a way for citizens to continue to participate in discussion and problem-solving in the aftermath of a tragedy (Mäkinen and Kuira, 2008).

Discuss the socio-political and scientific causes and implications of and responsibility for events

Post disaster, individuals frequently are motivated to determine why an event occurred, who or what is responsible for it (or to blame), and how to prevent it reoccurring (Bucher, 1957). This process can cause divisions and hostility in a community (Bucher, 1957), or, if done competently, can contribute to an efficacious, empowered, and resilient community (Norris et al., 2007). Since social media offers two-way communication that is available to a variety of users, it has the potential to help with the deliberative post-disaster process (Muralidharan et al., 2011). However, while this possibility exists, much more work is needed in the area to understand how to facilitate competent post-disaster community deliberation.

(Re)connect community members

Disasters, particularly those that generate significant destruction or force residents to evacuate, can fracture community links. Social media has the capacity to reconnect community members after an event while also forging new community connections as a result of the incident (Procopio and Procopio, 2007; Shklovski, Palen, and Sutton, 2008; Rive et al., 2012; Taylor et al., 2012). Following Hurricane Katrina, for instance, many residents of New Orleans, Louisiana, evacuated due to the storm. Once displaced, online discussion boards, arranged by specific neighbourhoods, allowed residents to reconnect ahead of returning home (Shklovski et al., 2010), to share stories, to procure information on the condition of their neighbourhoods, and to discuss plans to return home. Furthermore, new social media connections and communities that are developed due to a disaster may stay intact following the event (Bunce, Partridge, and Davis, 2012). Thus disaster social media has the potential to enhance social capital and connections, fostering community resilience (Norris et al., 2007; Procopio and Procopio, 2007).

Implement traditional crisis communication activities

In addition to the uses previously described, disaster social media also can be used for traditional crisis communication activities such as to 'restore organizational normalcy, influence public perception, and regain and repair image and reputation' (Jin, Pang, and Cameron, 2012, p. 267; see also Muralidharan, Dillistone, and Shin, 2011; Utz, Schultz, and Glocka, 2013). Implementing crisis communication activities is the sole disaster social media use that we posit as one-way communication, emanating from the organisation seeking to protect itself. The overall crisis communication process may involve listening to the public and talking to communities, thereby being a two-way process (Heath, Palenchar, and O'Hair, 2009), but the function of crisis communication is focused almost entirely on protecting the organisation's image. From an organisational perspective, the use of social media 'should complement traditional media during a crisis' (Austin, Liu and Jin, 2012, p. 16).

Implications for practice and research

The framework of disaster social media users and uses described here has several implications for practice and research. From a practical perspective, it illustrates the robust ways that social media can be employed to inform and improve disaster operations. However, the multifaceted and often chaotic nature of disasters and social media necessitate organisational and system planning and training in order to harness the potential of social media during a crisis. To date, as Bruns et al. (2012, p. 9) point out, the use of social media during a disaster 'is still emerging, and remains largely *ad hoc*'. The disaster social media framework provides an opportunity to standardise and organise disaster social media uses and users, and disaster systems can use this information to guide disaster operation plans. Furthermore, each category of disaster social media use described in the framework offers an opportunity for further disaster social media technical development and for increased social media integration in disaster operations. While significant work is needed to integrate fully these emerging social media into complex disaster systems, the possible benefit to individuals and society justifies the investment.

Similarly, from a research standpoint, the proposed framework provides an outline for future scholarship from a variety of perspectives and fields. Each of the disaster social media uses listed in Table 1 represents a possible line of academic study, and by drawing on the discussion of each social media use category, next steps for research quickly emerge. For example, for the disaster social media use category of 'Document and learn what is happening in a disaster', several areas of additional research are needed. These include: determining what characteristics of disaster social media content capture users' attention, contribute to learning, and motivate individuals to act; examining the prevalence of false information in initial disaster social media reports and exploring if and how such misinformation is corrected; identifying the structure of disaster social media conversations and locating important

information sources within that structure; and determining how to influence social media discussions of events.

Beyond research in each category of disaster social media use, future research can also take a comparative approach or cut across categories. For instance, while the framework utilises a broad definition of social media, specific social media platforms and services differ in many ways. Future research should assess whether specific social media platforms and services are better suited than others for certain disaster social media uses (Bruns et al., 2012). In addition, research should consider the role of computing devices as they relate to the employment and effectiveness of disaster social media. The ongoing shift towards the utilisation of mobile computing devices to access social media may have implications for how social media is used during a disaster and how individuals are affected by such use. For example, citizen journalist coverage of disasters that is captured by mobile computing devices and shared through social media may be more 'intimate' (Goggin, 2011) than traditional news coverage of these events and thus have different effects on individuals and communities. Finally, moving forward, the results of new research on disaster social media can be incorporated in the proposed framework, thereby increasing the synthesis and usability of the insights gained through ongoing disaster social media scholarship.

Conclusion

A framework of disaster social media users and uses was identified through a comprehensive literature review. This framework can be used to facilitate the development of disaster social media tools, the formulation of disaster social media implementation processes, and the scientific study of disaster social media effects. It illustrates that a variety of entities may both employ and produce disaster social media content. Hence, disaster social media use can be conceptualised as occurring at a number of levels, even within the same disaster.

While several disaster social media users and uses exist in this framework, it is not the case that, typically, each group of users and uses will map to a single social media source. More likely, a single social media source may be employed by different users for multiple, varying purposes. For example, the Joplin Tornado Information website and Facebook page (created following the tornado in Joplin, Missouri, on 22 May 2011)[5] was used by individuals within and without the affected community, by organisations, and by others, and it aimed to serve as a clearinghouse for disaster information, current needs and available resources, volunteer opportunities, and more (Williams, Williams, and Burton, 2012). Thus this social media site was utilised by different user groups and served several different functions. In addition, one disaster social media site may connect users to other disaster social media sites that have similar or complementary functions, thereby potentially extending the utility of any single starting point in the context of disaster social media. Finally, given the ongoing evolution of social media, the framework described here may also evolve over time. The proposed framework, however, can be adjusted and expanded as necessary to reflect any future technology changes.

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2   See http://earthquake.usgs.gov/earthquakes/dyfi/ (last accessed on 27 June 2014).

3   The official emergency telephone number in the UK and a number of other countries.

4   See https://safeandwell.communityos.org/cms/index.php (last accessed on 27 June 2014).

5   See http://joplintornado.info and https://www.facebook.com/joplintornadoinfo (last accessed on 3 July 2014).

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