

The Tweet Before the Storm: Assessing Risk Communicator Social Media Engagement During the Prodromal Phase – A Work in Progress

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ABSTRACT

Social media during the prodromal phase of the crisis lifecycle is critically understudied in the academic literature, as is the understanding of the role of engagement in these mediums by crisis responders and managers in helping the public prepare for a crisis event. This study analyzed 2.8 million tweets captured prior to the landfall of Hurricane Sandy. Risk communicators were identified and their tweets assessed for characteristics in the strategic use of Twitter and their levels of engagement with the general public. This work in progress provides a foundation for a longitudinal study analyzing future crisis events and measuring the growth of expertise and engagement in social media by crisis communicators.

Keywords

Risk communication, crisis response, social media, Twitter

INTRODUCTION

In 2011, in recognizing the need to establish protocols as social media became more integrated in emergency preparedness, response and recovery, the United States Department of Homeland Security (DHS) Science and Technology Directorate established a Virtual Social Media Working Group (VSMWG) to examine and define social media's role in crisis events and how government agencies may best utilize it as a resource. The results were three working papers released within the same year. The first paper, published in January 2012, "Social Media Strategy", sought to introduce social media as a strategic resource for use in public safety, introduce best practice sand case studies for responders, and discuss the overall challenges of using these new collaborative technologies (DHS VSMWG, 2012b).

The second paper released in the same month, "Next Steps: Social Media for Emergency Response", provided detailed next steps to implementing the recommendations from the first paper (of Homeland Security, Directorate, Security Enterprise, & Responders Group, 2012). The final working paper, released September 2012, "First Responder Communities of Practice Virtual Social Media Working Group Community Engagement Guidance and Best Practices", advocated "pre-engagement" with the community to build trust and credibility, and to encourage "multi-directional" sharing of information (DHS VSMWG, 2012a). The purpose of these working papers are to advocate the implementation of social media, devise strategy, and encourage engagement across federally associated crisis responders, emergency managers, and their affiliates with the general public.

Five weeks after the release of the final working paper, Hurricane Sandy made landfall on the east coast of the US. Hurricane Sandy was a tropical cyclone that formed in the central Caribbean before moving west toward the mid-Atlantic coast and strengthening into a hurricane in late October 2012. By landfall in New York and New

Jersey, Sandy transitioned into a post-tropical cyclone coinciding with the period of the month where tides were highest, creating simultaneously, the largest storm surge and storm wind field on record, and the costliest hurricane in the United States to date (US Department of Commerce, NOAA, 2012).

Following the devastation of the hurricane, in June 2013, the DHS VSMWG released a fourth working paper, “Lessons Learned: Social Media and Hurricane Sandy”, identified the event as the largest social media participation for government agencies and crisis management partners, and further, identified technology, process, and policy gaps that require action. Though recognizing the event as an advancement of the use of social media in many agencies, the report concedes that more work needs to be done in communicating with the public, among other areas, and recognized the need to pre-deploy technological solutions for slow-onset events (U.S. Department of Homeland Security, 2013).

The American Red Cross, a non-governmental organization, issued their own findings in 2013 reporting advice and emotional support offered through social media, and while they tracked over 2 million posts prior, during, and after the storm, like the DHS report, they too, offered only a short anecdote of their efforts (Cross, 2013).

Despite discussing the need to use social media as a two-way communication channel, and discussing explicit plans for implementation, none of the four working group reports, or American Red Cross report, addresses how to assess the failure or success of social media use. If the goal of utilizing social media in emergency preparedness and response is to “connect with citizens during all phases of a crisis” and enact appropriate “behavioral change”, then digital response and engagement should be understood according to the different phases of an emergency, where then the development of evaluation of efforts used becomes increasingly more necessary (DHS VSMWG, 2012b).

Craig Fugate, director of the Federal Emergency Management Agency (FEMA) has been an ardent advocate of social media and advises crisis responders and manager to use social media not just to push information out the public but to listen and engage through the various mediums (Stetler, 2012). Since the hurricane is recognized as a tipping-point for increased use of social media in crisis response community, using data garnered from the event, and parsed according the disaster phase. Deconstructing and describing the social media landscape by medium and by organization will provide a baseline by which future cases are compared and assessed. Such knowledge will help in the further establishment of protocols and standard to help improve the emergency management and crisis response use of social media.

To date little research has been performed on crisis responders’ use of social media by stage of crisis, nor with regards to engagement between responders and managers to the general public. In this paper, we look at tweets captured from the pre-crisis, or prodromal phase of Hurricane Sandy analyzing crisis responders as risk communicators and assessing their use frequency and engagement with the general public.

BACKGROUND

Emergency Preparedness

Emergency preparedness is the capability the inhabitants of a defined geographical area possess in effectively dealing with environmental threats and mitigating potential consequences with regards to physical and psychological health, and structural and technological systems (Tierney, Lindell, & Perry, 2001).

In Fiske’s four stages of the crisis, emergency preparedness takes place in the prodromal phase, where signals and alerts may occur, but before the actual onset of a crisis (Fiske & Taylor, 1991). Emergency preparedness involves the active cooperation between political jurisdictions and the potentially affected public where hazard assessment and risk reduction becomes are the main goals (Perry & Lindell, 2003).

Risk communication differs from crisis communication in that crisis communication addresses events as they happen or have happened, while risk communication addresses the time before an event becomes a crisis (Patric R. Spence, Kenneth A. Lachlan, Xialing Lin, 2015). Risk communication, as described by the National Research Council, is “an interactive process of exchange of information and opinion among individuals, groups, and institutions (Nelkin, 1989).” Risk communication also concerns itself with the public’s right to know about critical hazards and corresponding risks (Reynolds & Seeger, 2012).

For emergency preparedness, in lieu of in-person training, risk communication becomes paramount. In the traditional preparedness model, risk communication would occur via radio and television (Veil, Buehner, & Palenchar, 2011), however, with 76 percent of Americans on the Internet using social media (*Social Networking Use*, 2015), and 62 percent receiving their news from social media (Gottfried & Shearer, 2016), crisis responders and managers are well advised to integrate risk communication into their preparedness efforts (Merchant, Elmer, & Lurie, 2011).

Studying Social Media Pre-Crisis

Social media has been intensely studied in crisis response and management for over a decade. Since wikis and blogs were first used during Hurricane Katrina, we have seen social media emerge as a tool for knowledge management (Murphy & Jennex, 2006), community organization (Sutton, Palen, & Shklovski, 2008), situational awareness (McClendon & Robinson, 2012), rumor control (Mendoza, Poblete, & Castillo, 2010), and collaborative problem solving (Vieweg, Palen, Liu, Hughes, & Sutton, 2008).

Further, research has addressed the challenges of crisis responders using social distributed information in the form of information seeking behavior (Lachlan, Spence, & Lin, 2014), technical collection (Schulz & Probst, 2012), systems integration (Palen, Vieweg, & Anderson, 2010), and trust and credibility concerns prior, during, and after crisis events (Meier, 2011).

However, few studies focus on the prodromal or risk stage of impending events on social media. Though many crises, such as explosions or terrorist attacks, do not have a prodromal stage, many weather-related events such as hurricanes and snow storms, or spreading illnesses have a lag time between initial indications of the events potential onset and the actual onset.

Most research in the pre-crisis phase studied the use of social media as a detection method. Particularly in the case of Twitter, it has been studied as a way to detect conversation trends (Mathioudakis & Koudas, 2010), and emerging news stories (Petrović, Osborne, & Lavrenko, 2010), such as the emergency landing of US Airways Flight 1549 in the Hudson river (Landua, 2011). Twitter has also been studied as a soft-sensor for the signaling of potential impending crises such as earthquakes, where results were shown to have as much accuracy as traditional hard-sensors (Earle, Bowden, & Guy, 2011; Sakaki, Okazaki, & Matsuo, 2010), and as a tool to enhance situational awareness before a crisis has occurred (Crooks, Croitoru, Stefanidis, & Radzikowski, n.d.).

Two studies specifically looked at information in prodromal stage. Spence et al looked at the type of information on Twitter prior to Hurricane Sandy and discovered the quality of information tapers before crisis onset (Patric R. Spence, Kenneth A. Lachlan, Xialing Lin, 2015). A follow-on study by Lachlan et al, using the same data set, demonstrated that while Twitter is used to express perception of risk, how and why varies greatly by gender and demographic (Patric R. Spence, Kenneth A. Lachlan, Xialing Lin, 2015).

At issue with both these studies is that collection times were limited resulting in garnering 27,259 tweets as a macro sample and only 1700 in a micro sample being analyzed, during an event where over 20 millions tweets were generated (Twitter, 2012). Further, these studies only utilized the hashtag “sandy” when other popular terms were trending. Lastly, only one study looked specifically at what they deemed to be crisis responders, the National Oceanic and Atmospheric Administration (NOAA) and the Centers for Disease Control (CDC), when neither organization would be responsible for direct emergency management, and not necessarily considered the typical risk communicators the general public would look to prior to a crisis.

Defining Engagement

Engagement and crisis response on social media is a similarly under-studied area. Researchers assert many crises may be avoidable through proactive listening and engagement on behalf of crisis responders (Veil et al., 2011). Not only through the promotion of preventative action, but by providing emotional support as well. Coombs and Holladay discovered the type of support the public receives across all channels of communication can affect the public’s attitude towards crisis response strategies (Coombs & Holladay, 2005).

For organizations that have adopted social media as a part of a communications strategy, many have policies restricting and limiting its use as a one-way push of communication rather than as an online dialogue (Baron & Philbin, 2009). For those using social media in a dialogic fashion, research suggests that this enhances community engagement, which in turn builds trust and social capital in the crisis communicators (Yang, Kang, & Johnson, 2010).

According to Twitter, engagement is defined as the “total number of times a user interacted with a Tweet. Clicks anywhere on the Tweet, including Retweets, replies, follows, likes, links, cards, hashtags, embedded media, username, profile photo, or Tweet expansion (“Tweet Activity Dashboard,” 2016).” Another metric, the engagement rate, is the number of engagements divided by the number of impressions – the impressions being the number of times a Twitter user sees a tweet in their timeline or search results.

Thus, if specific preparations can help mitigate or offset potentially devastating effects of a crisis, and if social media is becoming the preferred method of Americans receiving news regarding impending crises, and if engagement is essential to building cooperation and trust during crisis events:

RQ1: With what frequency did risk communicators communicate during the prodromal phase of Hurricane Sandy?

RQ2: To what level did risk communicators engage with the general public during the prodromal stage of Hurricane Sandy?

RQ3: What does the level of frequency and engagement infer regarding risk communicators' overall use of Twitter during this event?

RQ4: How might assessing frequency and engagement inform the future practices of risk communicators?

DATA AND METHODS

From October 26, when the states of New York, Maryland, Washington, Pennsylvania, North Carolina, and Maine declared a state of emergency after Sandy passed over the Bahamas in the Caribbean (CNN Library, 2015), thru October 29, 2012, prior to Sandy's landfall in New York and New Jersey, 2.8 million tweets were captured referencing the top trending words: Sandy, Hurricane, and Hurricane Sandy (CNN Library, 2015; Twitter, 2012). From this data set, 192 persons and organizations responsible for emergency or humanitarian response, or communicating information regarding crisis and risk were targeted for additional analysis resulting in a sample of 1,895 tweets available for further analysis.

The organizations identified included Federal Emergency Management Agency (FEMA) and the American Red Cross, the National Weather Service, the National Oceanic and Atmospheric Administration (NOAA), and their various regional offices, the American Red Cross and its many offshoots, the National Weather Service, state and local emergency management, city mayors, state governors, police and fire departments, the United State Coast Guard, and the Whitehouse. Officials, such as FEMA Director Craig Fugate, Newark, New Jersey Mayor Cory Booker, and other persons identified as working or affiliated with the above referenced organizations.

These organizations and persons were first coded by class and by mission. Class is determined by whether the Twitter account was federal, state, city, or non-governmental organization. Mission was determined by the type of activity the person or organization is responsible for: emergency management, humanitarian relief, security, governance, or weather.

Each tweet was coded for the absence or presence of a hyperlink, the response to a private person's account, a government or non-governmental organization, or a media or business account. Likewise, the data was coded for retweets to previously mentioned account types. Further, data was coded trending hashtags (sandy, hurricane, hurricanesandy, Frankenstorm), off-topic hashtags, or tweets that contained plain text without any of the previous mentioned elements.

Since the internal metrics of risk communicators was unavailable for study, for the sake of this research, a two-tier approach to publicly available information regarding engagement was used.

The first tier, active engagement is defined as the direct reply (or '@') from a risk communicator to another person or organization Twitter account, or a Retweet (or 'RT') from a risk communication to another person or organization. The second-tier, or passive engagement reflects the number of times a risk communicator liked or favorited (reflected on Twitter as heart-shaped symbol).

A single researcher coded the 1895 tweets of interest for this study. However, two assistants were trained on the same coding schematics and re-coded the data. As the analysis was performed on binary variables, percent agreement was performed and a coefficient of .95 was achieved for intercoder reliability. For communication studies, Lombard et al recommend a coefficient of .90 or higher (Lombard, Snyder-duch, & Bracken, 2002), fully .10 above the standard normally employed (Neuendorf, 2002).

INITIAL FINDINGS

Out of the 2.8 million tweets collected from October 26 to October 29, 1895 tweets from 191 persons or organizations affiliated with emergency response or crisis management were identified and analyzed. These tweets constitute .0007 percent of the total tweets captured. Of the 191 persons or organizations, this amounts to a daily average of 2.47 tweets, and an average of 9.92 tweets overall. Of the 1895 tweets analyzed, 79 percent occurred on 27 and 28 October.

The range of tweets sent during this time is from 1 to 265 (see Table 1). Thirty-three percent of the tweets fall within the 21 to 50 tweet range and were sent by 10 percent of the organizations. Four organizations, or 2 percent overall, sent 28 percent of the tweets. However, of these four organizations, two of the entities' tweets are automatically generated. Sixty-three percent of the organizations ranged from 1 to 5 total tweets prior to

landfall of the hurricane.

Table 1. Tweets range and percentage of analyzed tweets.

| Tweet Range | 1 | 2-5 | 6-10 | 11-20 | 21-50 | >50 |
|--------------------|----------|------------|-------------|--------------|--------------|---------------|
| # Organizations | 55 | 64 | 31 | 18 | 20 | 4 |
| % Organizations | 0.29 | 0.34 | 0.16 | 0.09 | 0.10 | 0.02 |
| # Tweets | 55 | 197 | 235 | 265 | 620 | 523 |
| % All Tweets | 0.03 | 0.10 | 0.12 | 0.14 | 0.33 | 0.28 |

Of the 1,895 tweets analyzed, 63 percent inserted hyperlinks to information on preparedness or news updates (see Table 2). Sixty-five percent of tweets also contained the hashtags: Sandy, Hurricane, or HurricaneSandy, either alone or mixed with other hashtags, however, 168 tweets, or 9 percent, contained hashtags that were either self-branded or attributable to topics outside of the hurricane. A low percentage of tweets contained plain text, that is, posts made with no links, hashtags, hyperlinks, replies or retweets.

Of the 192 organizations, 34 percent of their tweets were retweets (RT) of private person, government or non-governmental organizations, and media or business (see Table 2). Direct replies (@) were limited to just 14 percent to the same entities.

Table 2. Elemental breakdown of analyzed tweets.

| Tweets Containing: | Number | % Org Tweets |
|---------------------------|---------------|---------------------|
| Hyperlink | 1199 | 0.63 |
| @ Private Person | 52 | 0.03 |
| @Government/NGO | 158 | 0.08 |
| @Media/Other | 54 | 0.03 |
| RT Government/NGO | 484 | 0.26 |
| RT Media/Other | 114 | 0.06 |
| RT Private Person | 37 | 0.02 |
| Plain Content | 51 | 0.03 |
| Trending/Mix # | 1234 | 0.65 |
| Off-Topic # | 168 | 0.09 |

In categorizing the tweets by class, accounts through the federal government posted 751 tweets, 40 percent (see Table 3). State accounts closely follow with 34 percent. When looking at the subset by mission, governance accounts posted the most tweets, followed by weather and closely followed by emergency management. Law enforcement posted the least amount of tweets with 2 captured during the prodromal period.

Table 3. Tweets posted by class and mission.

| Class | Emergency | Governance | Humanitarian | Law | Security | Weather | Total |
|--------------|------------------|-------------------|---------------------|------------|-----------------|----------------|--------------|
| NGO | | | 337 | | | | 337 |
| FEDERAL | 239 | 3 | | | 51 | 458 | 751 |
| STATE | 143 | 451 | | 2 | 43 | | 639 |
| CITY | 57 | 111 | | | | | 168 |
| Total | 439 | 565 | 337 | 2 | 94 | 458 | 1895 |

Overall, most communicators recognized the 140 character limitation and used external links to connect people to more information. The American Red Cross in particular, regularly encouraged the public to download a special smartphone app for Hurricane Sandy in order to help people prepare for the storm, receive alerts, and monitor places of interest (see Figure1).



Figure 1. @redcrossny encouraging the public to download a special app for Hurricane Sandy.

By class, federal and state accounts are closely matched, with the majority of federal posts coming from weather-related accounts, while the majority of state posts coming from governance-related handles.

For NGOs, despite the proliferation of Red Cross handles, and the media campaign to promote their Hurricane Sandy preparation app for mobile phones, there were only 337 tweets across 59 various Red Cross affiliated accounts. Four accounts, Central Massachusetts, New York, Philadelphia, and the main account, contributed to the bulk of the tweets, a logical occurrence given the proximity of these areas to the projected landfall of the hurricane.

By class, law enforcement had the least amount posts, only 2 during the prodromal stage, however this is not surprising given that, at least in New York City, the majority of precincts did not even have Twitter accounts until April 2014. This is lack of activity and absence of account is of less concern considering that law enforcement tends to be reactive presence in crisis management as opposed to proactive.

In light of the fact that more than 20 million tweets were posted before, during, and after the event (Twitter, 2012), the number of tweets posted by communicators, even considering the retweets of their posts by the general public, is considerably less than one percent of the overall tweets. Further, of the 192 persons and organizations identified, twenty accounts, 10 percent, were responsible for 33 percent of the tweets. Of the top tweeters within this group, there were 4 organizations that posted over 50 tweets during this pre-crisis period, and two of these accounts send automated tweets posting weather updates.

Inconsistent use of hashtags has long been a problem for those new or unfamiliar with Twitter (Potts, Jones, Seitzinger, & Harrison, 2011). Organizations will often self-promote through hashtagging, but when a trending topic has been established, using a popular hashtag makes it easier to search for information on a specific topic, and if a person or organization does not hashtag accordingly, they risk getting lost in the stream of tweets.

As Sandy fluctuated between a low-grade hurricane, a winter storm, and a tropical storm, the posts from the National Weather Service (@National_WX) general twitter account reflected the change. However, without referencing “Sandy”, in either plain text or via hashtag, only 13 of their 72 tweets are searchable by the trending term. The National Weather Service satellite office for Lake Charles, Louisiana (@NWS_LCH) posted 112 automated tweets prior to landfall, but still mentioned Sandy in all but 4 posts. These 4 posts still contained the “hurricane” keeping the post on topic. These two examples exhibit the benefits and downfalls of automation. With forethought and planning, automation has the potential to be relevant to the social conversation at hand, or potentially excluded.

Overall, with such low frequency of posting during the prodromal stage of the crisis, risk communicators can ill-afford having 9 percent of their tweets lost in the social stream with off-topic hashtags or plain text that does not strategically keep their tweets in the public conversation.

Other forms of more direct engagement with the general public were extremely limited. Direct engagement by either responding to a tweet of a private person or retweeting their post constituted 5 percent of all risk communicator tweets. Most persons and organizations responded or retweeted like entities (29 percent) or media and businesses (14 percent). Responding directly to or retweeting like entities has the potential for creating an

echo-chamber effect, but in this context of an impending crisis, it would likely be seen as trusted advice from recognizable sources, and given the many permutations of FEMA, the National Weather Service, and the American Red Cross, consistency of message is key and may be more important in this case.



Figure 1. Delaware Governor, Jack Markell, was prolific in direct response prior to Hurricane Sandy.

Official accounts of public figures posted the most replies to the general public. The most engaged during this event was the account of Governor Markell of Delaware, who directly responded to 25 tweets out of 35 prior to landfall, answering questions, and updating and correcting information (see Figure 1). Cory Booker, former mayor of Newark, New Jersey, also replied to numerous private persons during this time.

According to the final lessons learned from the DHS VSMWG, from 22 October thru landfall, the Red Cross tagged 10,447 tweets and Facebook posts for “further consideration”, and following the landfall, had responded to 2,386 of the posts [39]. Communication with the American Red Cross did not yield information regarding the amount of time between tagging a tweet for consideration and when the response occurred.

Despite claims of having responded to thousands of social media posts [4], during the prodromal phase, the Red Cross responded to 9 tweets in the data set, 2 of which were a thank you to celebrities for acknowledging them in their own tweets. This suggests either a greater emphasis is placed on other phases of the emergency, or a greater emphasis was placed on Facebook during the prodromal phase. This can be problematic when people are searching for preventive solutions, and also given the fact that despite the phase of the emergency, certain social media platforms serve increasingly narrower demographic groups [7]. However, in this same tweet set, the 31 tweets the Red Cross posted were retweeted 2133 times and favorited 215. FEMA responded to 1 question during this time frame, but of their 26 tweets, they were retweeted 4605 times and favorited 397. While one direct response may not meet the spirit of successful engagement, it is unclear whether a metrics based approach suffices as no definition for the mandate of “successful engagement” is provided within the DHS VSMWG working papers.

DISCUSSION

Previous research suggests that risk communicators should advise specific behavior with a “degree of alarm that is enough to motivate but not paralyze” and “lead audiences to make ideal decisions concerning the protection of life, health, and property (Lachlan, et al., 2014).” This type of communication not only requires a well-crafted message, but technically requires the preferred medium of communication be used to its maximum potential, and that communicators engage rather than broadcast in order to help empower citizens (Seeger, 2002), particularly since 62 percent of Internet users now receive news through social media (Gottfried and Shearer, 2016).

In general, given the large number of social media adoption by the US general public in 2012, Hurricane Sandy appears to be a missed opportunity for risk communicators to engage, and largely demonstrates a low level of social media savvy exhibited by most organizations studied in this work. DHS’s lack of assessment development and benchmarking prior to the event means there is no standard by which to measure the success or the failure of risk communicators. Even outside of the government structure, when contacted about practices in internal assessment and benchmarking on their social media use, the American Red Cross referred back to simple metrics provided by Twitter and Facebook with indication of whether they assess themselves longitudinally.

As social media increasingly becomes the way that news and information is disseminated across the general public, and given the number of social media and closed networking sites that have risen in use since 2012 (i.e. Snapchat, Instagram, Pinterest, etc.), they need for gauging effective use across channels becomes ever more important. To maximize the potential of any medium, higher instances of direct engagement may be required by emergency managers and risk communicators to become proactive as opposed to only reactive in the time leading up crisis events.

Developing frameworks for assessment and comparing assessments of crisis events over time will help risk

communicators, both governmental and NGO alike, to develop better practices and protocols. One cannot determine the success or failure is one does not performs the simple act of counting and establishing a baseline for minimum performance. Further, emergency managers should consider the value of engagement in promoting behavior that either prevents or mitigates the effects slow moving disasters may have on the affected public. Crisis events that can be forecasted, even with as little as 24 hour notice, provide a window of opportunity for the public to respond appropriately, provided skilled emergency professionals place equal emphasis on proper communication across all phases of the event.

LIMITATIONS AND FUTURE WORK

The data collected for this study was limited to those tweets containing the three most popular hashtags used prior and during the onset of the storm. Additionally, Twitter is known to limit full access to data, even within its own search API, thus there is no way of knowing how many tweets failed to be captured.

Twitter is one of many popular social media platforms used in the United States, hence, this study does not account for engagement levels in Facebook, Instagram, or other social media platforms.

Further, the analysis presented here reflects one moment in time, prior to crisis onset, in 2012. This research does not account for advancements in access and use of social media across crisis response and humanitarian organizations since that time.

As this study only focused on the use of Twitter during Hurricane Sandy, an additional study on the use of Facebook during this time frame would be useful in providing a more well-rounded assessment.

Using this study as a baseline, future research will involve the data capture of tweets and Facebook posts during another slow moving, impending event such as a hurricane or snowstorm. Using 2012 as a baseline, the maturity of use among crisis and risk communicators may be assessed.

Lastly, an additional study is required to assess information seeking behavior in the form of direct question posting. Is the public actually asking questions in this medium? In active or passive information seeking, identifying whether the general public asks for information in this medium or only searches Twitter for information regarding preparation and action would address this question.

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REFERENCES

- Baron, G., & Philbin, P. (2009). Social media in crisis communication: Start with a drill. *Public Relations Tactics*. Retrieved from https://www.prsa.org/SearchResults/view/7909/105/Social_media_in_crisis_communication_Start_with_a_#.V5eyhq4wgpk
- CNN Library. (2015). Hurricane Sandy Fast Facts. Retrieved July 11, 2016, from <http://www.cnn.com/2013/07/13/world/americas/hurricane-sandy-fast-facts/>
- Coombs, W. T., & Holladay, S. (2005). *The effect of affect in organizational settings*. (N. M. Ashkanasy, W. J. Zerbe, & C. E. J. Härtel, Eds.) (Vol. 1). Elsevier JAI.
- Crooks, A., Croitoru, A., Stefanidis, A., & Radzikowski, J. (n.d.). #Earthquake: Twitter as a Distributed Sensor System. <https://doi.org/10.1111/j.1467-9671.2012.01359.x>
- Cross, A. R. (2013). *Superstorm Sandy: One-Year Update*. Washington DC. Retrieved from http://www.redcross.org/images/MEDIA_CustomProductCatalog/m23216738_Superstorm_Sandy_One-Year_Update.pdf
- DHS VSMWG. (2012a). *First Responder Communities of Practice Virtual Social Media Working Group Community Engagement Guidance and Best Practices*. Washington DC. Retrieved from https://www.dhs.gov/sites/default/files/publications/Virtual_Social_Media_Working_Group_VSMWG_Community_Engagement-508.pdf
- DHS VSMWG. (2012b). *Social Media Strategy*. Washington DC. Retrieved from https://www.dhs.gov/sites/default/files/publications/Virtual_Social_Media_Working_Group_VSMWG_Social_Media_Strategy.pdf

- Duggan, B. Y. M., & Smith, A. (2013). Social Media Update 2013. *Pew Research Internet Project*, 7–9.
- Earle, P. S., Bowden, D. C., & Guy, M. (2011). Twitter earthquake detection: earthquake monitoring in a social world. *ANNALS OF GEOPHYSICS*, 54(6). <https://doi.org/10.4401/ag-5364>
- Fiske, S. T., & Taylor, S. E. (1991). *Social Cognition* (2nd ed.). New York, NY: McGraw-Hill.
- Gottfried, J., & Shearer, E. (2016). *News Use Across Social Media Platforms 2016*. Washington DC. Retrieved from <http://www.journalism.org/2016/05/26/news-use-across-social-media-platforms-2016/>
- Lachlan, K., Spence, P., & Lin, X. (2014). Expressions of risk awareness and concern through Twitter: On the utility of using the medium as an indication of audience needs. *Computers in Human Behavior*, 35, 554–559.
- Landua, D. A. (2011). *How Social Media is Changing Crisis Communication: A Historical Analysis*. Fairleigh Dickinson University.
- Lombard, M., Snyder-duch, J., & Bracken, C. C. (2002). Content Analysis in Mass Communication. *Human Communication Research*, 28(4), 587–604. <https://doi.org/10.1111/j.1468-2958.2002.tb00826.x>
- Mathioudakis, M., & Koudas, N. (2010). TwitterMonitor: Trend Detection over the Twitter Stream. *Proceedings of the 2010 International Conference on Management of Data*, 1155–1157. <https://doi.org/10.1145/1807167.1807306>
- McClendon, S., & Robinson, A. C. (2012). Leveraging Geospatially-Oriented Social Media Communications in Disaster Response. In L. Rothkrantz, J. Ristvej, & Z. Franco (Eds.), *Proceedings of International ISCRAM Conference 2012* (pp. 2–11). Vancouver.
- Meier, P. (2011). Seeking the Trustworthy Tweet: Can “Tweetsourcing” Ever Fit the Needs of Humanitarian Organizations? Retrieved from <http://irevolution.net/2011/06/05/tweetsourcing/>
- Mendoza, M., Poblete, B., & Castillo, C. (2010). Twitter Under Crisis: Can we trust what we RT? In *New York* (pp. 71–79). ACM Press. Retrieved from <http://research.yahoo.com/pub/3255>
- Merchant, R. M., Elmer, S., & Lurie, N. (2011). Integrating Social Media into Emergency-Preparedness Efforts. <http://dx.doi.org/10.1056/NEJMp1103591>.
- Murphy, T., & Jennex, M. E. (2006). Knowledge Management, Emergency Response, and Hurricane Katrina. *INTERNATIONAL JOURNAL OF INTELLIGENT CONTROL AND SYSTEMS*, 11(4), 2006–199.
- Nelkin, D. (1989). Construction of Risk Perception. *Annu. Rev. Public Health*, 10, 95–113.
- Neuendorf, K. A. (2002). Defining Content Analysis. *The Content Analysis Guidebook*, 1–25. Retrieved from [https://www.google.com.br/#q=Neuendorf+K.++\(2002\)+The+Content+Analysis+Guidebook.+Sage+Publications+Inc.,+Thousand+Oaks,+CA.](https://www.google.com.br/#q=Neuendorf+K.++(2002)+The+Content+Analysis+Guidebook.+Sage+Publications+Inc.,+Thousand+Oaks,+CA.)
- of Homeland Security, D., Directorate, T., Security Enterprise, H., & Responders Group, F. (2012). *Next Steps: Social Media for Emergency Response*. Washington DC. Retrieved from https://www.dhs.gov/sites/default/files/publications/Virtual_Social_Media_Working_Group_VSMWG_Next_Steps_Social_Media_for_Emergency_Response.pdf
- Palen, L., Vieweg, S., & Anderson, K. M. (2010). Supporting “Everyday Analysts” in Safety- and Time-Critical Situations. *The Information Society*, 27(1), 52–62. <https://doi.org/10.1080/01972243.2011.534370>
- Patric R. Spence, Kenneth A. Lachlan, Xialing Lin, & M. del G. (2015). Variability in Twitter Content Across the Stages of a Natural Disaster: Implications for Crisis Communication. *Communication Quarterly* 63, 63(2), 171–186. <https://doi.org/10.1080/01463373.2015.1012219>
- Perry, R. W., & Lindell, M. K. (2003). Preparedness for Emergency Response: Guidelines for the Emergency Planning Process. *Disasters*, 27(4), 336–350.
- Petrović, S., Osborne, M., & Lavrenko, V. (2010). Streaming first story detection with application to Twitter. In *HLT '10 Human Language Technologies: The 2010 Annual Conference of the North American Chapter of the Association for Computational Linguistics* (pp. 181–189). Stroudsburg, PA: Association of Computational Linguistics. Retrieved from <http://portal.acm.org/citation.cfm?id=1857999.1858020>
- Potts, L., Jones, D., Seitzinger, J., & Harrison, A. (2011). Tweeting Disaster: Hashtag Constructions and Collisions. In *SIGDOC'11*. Pisa, Italy: ACM. <https://doi.org/978-1-4503-0936>
- Reynolds, B., & Seeger, M. (2012). *Crisis and Emergency Risk Communication*. Retrieved from http://emergency.cdc.gov/cerc/resources/pdf/cerc_2012edition.pdf
- Sakaki, T., Okazaki, M., & Matsuo, Y. (2010). Earthquake Shakes Twitter Users: Real-time Event Detection by Social Sensors. In *WWW 2010, April 26-30* (pp. 851–860). Raleigh, North Carolina: ACM.

- Schulz, A., & Probst, F. (2012). Crisis Information Management in the Web 3.0 Age. In *Proceedings of International ISCRAM Conference 2012* (pp. 2–6). Vancouver.
- Seeger M.W., Venette, S., Ulmer, R. R., & Sellnow, T. (2002). Media use, information seeking, and reported needs in post crisis contexts. In B. S. Greenberg (Ed.), *Communication and terrorism: Public and media responses to 9/11*. Hampton Press.
- Social Networking Use*. (2015). Washington DC. Retrieved from <http://www.pewresearch.org/data-trend/media-and-technology/social-networking-use/>
- Stetler, L. (2012). FEMA’s Fugate says Social Media is Valuable, but “No Tweet Stops the Bleeding.” *INPublic Safety*. Retrieved from <http://inpublicsafety.com/2012/02/femas-fugate-says-social-media-is-valuable-but-no-tweet-stops-the-bleeding/>
- Sutton, J., Palen, L., & Shklovski, I. (2008). Backchannels on the Front Lines : Emergent Uses of Social Media in the 2007 Southern California Wildfires. *Crisis*, (May), 1–9. Retrieved from <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.156.9517&rep=rep1&type=pdf>
- Tierney, K. J., Lindell, M. K., & Perry, R. W. (2001). *Facing the Unexpected: Disaster Preparedness and Response in the United States. Soil Tillage Research* (Vol. 5). Joseph Henry Press. Retrieved from <http://books.google.de/books?id=iHPF67ufgU4C>
- Tweet Activity Dashboard. (2016). Retrieved July 26, 2016, from <https://support.twitter.com/articles/20171990#>
- Twitter. (2012). People sent more than 20 million Tweets about the storm between Oct 27 & Nov 1. Terms tracked: “sandy”, “hurricane”, #sandy, #hurricane. Retrieved July 8, 2016, from <https://twitter.com/twitter/status/264408082958934016>
- U.S. Department of Homeland Security. (2013). *Lessons Learned: Social Media and Hurricane Sandy June 2013*. Washington DC. Retrieved from <https://www.dhs.gov/sites/default/files/publications/Lessons Learned Social Media and Hurricane Sandy.pdf>
- US Department of Commerce, NOAA, N. W. S. (2012). Hurricane Sandy. Retrieved July 19, 2016, from <http://www.weather.gov/okx/HurricaneSandy>
- Veil, S. R., Buehner, T., & Palenchar, M. J. (2011). A Work-In-Process Literature Review: Incorporating Social Media in Risk and Crisis Communication. *Journal of Contingencies and Crisis Management*, 19(2), 110–122. <https://doi.org/10.1111/j.1468-5973.2011.00639.x>
- Vieweg, S., Palen, L., Liu, S. B., Hughes, A. L., & Sutton, J. (2008). Collective Intelligence in Disaster : Examination of the Phenomenon in the Aftermath of the 2007 Virginia Tech Shooting. *Intelligence*, (May), 44–54. Retrieved from <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.156.7056&rep=rep1&type=pdf>
- Yang, S.-U., Kang, M., & Johnson, P. (2010). Effects of Narratives, Openness to Dialogic Communication, and Credibility on Engagement in Crisis Communication Through Organizational Blogs. *Communication Research*. <https://doi.org/10.1177/0093650210362682>