Social Media and Emergency Management: Exploring State and Local Tweets

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Abstract

Social media for emergency management has emerged as a vital resource for government agencies across the globe. In this study, we explore social media strategies employed by governments to respond to major weather-related events. Using social media monitoring software, we analyze how social media is used in six cities following storms in the winter of 2012. We listen, monitor, and assess online discourse available on the full range of social media outlets (e.g., Twitter, Facebook, blogs). To glean further insight, we conduct a survey and extract themes from citizen comments and government’s response. We conclude with recommendations on how practitioners can develop social media strategies that enable citizen participation in emergency management.

1. Introduction

The use of Web 2.0 enabled social media allows government agencies to engage the citizenry in new ways (Smith, 2010). Social media refers to the array of technologies that allow individuals to post, or re-post, their thoughts, pictures, and comments in a public forum. It enables individuals to share ideas, form communities, and coordinate their actions across time and space (Boyd 2008). Understanding the implications of social media is particularly important for public managers because the discourse captured by social media reflects the moods, values, and attitudes of citizens. It is particularly important for government executives to understand how to use social media effectively during a crisis.

2. Social Media Listening

Social Media refers to the class of technologies that enable individuals to reach out and connect with other “humans, create a relationship, [and] build trust. [9]” Numerous studies have explored social media utilization [7, 8].

Across the public, private, and non-profit sectors, organizations use social media to engage stakeholders, either by “sending” a message or “listening” to comments. By sending a message, organizations seek to realize diverse positive outcomes such as increasing brand awareness or mobilizing online communities that support their activities or products [9]. Within the domain of e-government, research has started to examine ways to use social media to more effectively project a voice to key stakeholders and broad communities served by public organizations [8].

Because monitoring software aggregates data across social media platforms and news services (see for example Brandwatch or Radian6), organizations are able to follow stakeholders’ conversations as they move from websites such as YouTube or Facebook to outlets such as Twitter or Vine to news services such as CNN or FoxNews. Through analyzing aggregated data, organizations are able to distinguish among influencers (i.e., people who shape opinions on many topics), brand ambassadors (i.e., people who focus on a specific brand), or the average social media user. By achieving a deeper understanding of the conversation and the roles that social media users play in those conversations, organizations can make strategic decisions about how to respond to issues, comments, and reports of product defects using diverse social media platforms such as Facebook, blogs, or LinkedIn. For private organizations, such social media strategies are important because negative affect towards the organization or its products can result in diminished brand loyalty or weaker sales [6].

3. Emergency Response Management

One of the most promising applications of social media is in crisis management [5]. During recent crises such as the 2010 flood in Pakistan, the 2011 earthquake in Japan and the 2011 flood in Thailand, social media has served as a the go-to-technology for numerous people seeking to share information about
their personal status, to request resources, or to report on the status of their community. In part, this is due to social media providing an innovative platform that enables users to easily share information without the constraints imposed by distance, time, or space [4].

4. Multi-Study Strategy

To evaluate the extent to which city and local governments in the United States used social media to manage emergencies, we conducted a four studies: Study 1 – we used exploratory means (interviews, searches and software) to define the important keywords. Study 2 - monitored online activity on diverse social media outlets (e.g., Twitter, Facebook, blogs) in six cities in the United States during January, February, and March of 2012. In Study 3 we used semantic analysis to help understand the concepts and themes of the dataset assembled in Study 2. Finally, in Study 4, we gathered data using a survey to understand the validity of the themes and concepts derived from the semantic analysis.

4.1 Study 1: Defining the Keywords

In phase one, we developed a systematic social media listening strategy for winter weather related events. Our listening strategy used a keyword set generated through a systematic review of the weather related sources of information, interviews with an expert on weather, and analysis of posts, comments, and tweets by citizens in a narrowly defined set of cities.

First, the researchers met to identify sources of weather related terms and keywords. We sought to incorporate sources that a) used technical language to describe weather, b) widely disseminated information on weather events, and c) represented popular culture. We integrated information from diverse weather related sources including websites such as weather.com, news outlets such as CNN.com and the New York Times, as well as the popular press such as People magazine. Integrating a diverse range of sources was important, because we wanted to capture not only the technical and media perspective of weather but also the pop culture view of storms. Our review of outlets, articles, and posts resulted in 39 weather related and disaster management terms.

Second, we met with a meteorologist to discuss the language used to describe weather in different science, news, and popular press outlets. Prior to our meeting, we asked the meteorologist to create an independent list of categories and terms that serve as indicators of severe weather. At the meeting, the meteorologist provided terms specific to severe weather, winter weather, and precipitation as well as terms used by the National Weather Service and storm prediction centers. We also confirmed our suspicion that each winter new terms surface in popular culture to describe specific storms and weather events. We used a total of 74 weather-related keywords in this study.

Third, we entered the terms in the Radian6 marketing cloud platform. Radian6 is an enterprise level social media monitoring and engagement platform offered by the Salesforce.com Marketing Cloud. We analyzed this content to identify terms to exclude, from popular discussions by citizens around weather and weather information providers. This step is necessary, because there may be a disconnect between the terms employed by academics (e.g., the investigators and meteorologists) and citizens to describe weather and weather related activities. Of
equal importance, this enabled exclude references to locations or teams whose nicknames are associated with weather related events such as the Colorado Avalanche hockey team.

We used a stratified sampling approach to identify cities with a high likelihood of having weather related conversations. We were interested in evaluating cities that had large amounts of precipitation and were either likely to have robust emergency management strategies or well-developed social media strategies. To ensure we captured variance in emergency management and social media strategies, we stratified our sample by population size. Based on our criterion, we monitored conversations in six cities, two small, two medium, and two large:

- **Buffalo, New York** 261,310 (small)
- **Anchorage, Alaska** 291,826 (small)
- **Denver, Colorado** 600,158 (medium)
- **Seattle, Washington** 608,660 (medium)
- **Chicago, Illinois** 2,695,598 (large)
- **New York, New York** 8,175,133 (large)

We constructed lists of the cities’ formal names and nicknames based on lists found in official city homepages as well as on Wikipedia.

### 4.1.1. Results from Study 1

Across the cities, we found a diverse set of social media strategies. Most cities utilize a diverse array of social media tools. Facebook and Twitter are the most popular, followed by RSS Feed. In addition to the seven tools that we included in our search, other tools utilized by city managers to interact with citizens include YouTube, Instagram, Flickr, Nixle, Tumblr, Foursquare, email and texts. Most cities use at least one social media tool to engage the citizenry. Surprisingly, at the time of this report, Buffalo, New York was the only city that did not use social media, while Seattle, Washington utilizes the most social media tools to interact with its constituents.

Our search results must be interpreted with caution, because cities often do not engage in centralized social media strategies. In large, complex cities such as Buffalo, it very well could be that specific departments have social media strategies that are not readily identifiable.

We constructed searches for conversations around each of our target cities. We entered each of our keywords about weather in Boolean searches that included the names or the nicknames of our target cities. Sample searches included snow and Denver or snow and Mile High City. We constructed searches that included concatenations of each of our keywords with city names and nicknames, irrespective of whether a major winter weather event had occurred during January, February, or March.

### 4.2 Study 2: Monitor

After constructing the keyword searches in Study 1, we monitored social media conversations during the first quarter of 2012. While doing so, we engaged in an iterative process of listening, monitoring, and analysis that resulted in more narrowly focused sets of results. We conducted two stages of analysis. The first stage was conducted within a social media listening platform. The purpose of this analysis was to achieve a high level understanding of how social media was used to respond to, discuss, and respond to weather emergencies. In the second stage of analysis, we exported aggregated data into Leximancer, a content analysis tool, a means to achieve a deeper understanding of themes, language, and issues across our selected cities. By integrating a more advanced content analysis tool into our study, we hoped to move beyond “listening and describing” the conversations to elicit themes relevant to a broad cross section of local and city managers.

We used Radian6 to monitor the use of these keywords across various social media platforms for a three-month period. Radian6 aggregates and curates social media posts across 150 million plus feeds such as blogs, Twitter, Facebook, LinkedIn and Youtube. It makes possible tracking trends, identifying key influencers, developing lists of key terms, and evaluating engagement across platforms [7]. By using Radian6, we were able to evaluate the breadth of conversations that mention weather events in the same post as the name of our target cities.

Our initial search generated more than 750,000 posts associated with our weather keywords and city names. Screening of the data indicated that our searches included posts that were not related to weather events; rather, they were relevant to

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1 Population sizes taken from the following websites: [citypopulation.de/USA-Cities.html#Stadt_gross](http://citypopulation.de/USA-Cities.html#Stadt_gross), [census.gov/geo/www/us_regdiv.pdf](http://census.gov/geo/www/us_regdiv.pdf)
professional sports teams (e.g., hockey teams such as the Colorado Avalanche), aspirations (e.g., I wish it would snow), and food (e.g., I want a Dairy Queen Blizzard). As a result, we constructed a series of terms of exclusion from the dataset. Specifically, we excluded terms that referred to specific sports teams, wishes, and products that were not directly relevant to our search for conversations about weather events.

Although screening the data reduced the dataset size to 168,000 posts, we found that our hit rate of off-topic posts was unacceptably high. For example, posts from New York City, reflected observations about tornadoes in Kansas City. Because we were not able to effectively screen by location or idioms, we manually screened the data. After eliminating spam and duplicates we ended up with a dataset of 71,663 posts from three platforms: Facebook (19,918), Flickr (2,518) and Twitter (49,227).

4.2.1. Results from Study 2

From December 30, 2011–March 30, 2012, there were posts on numerous social media networks, including blogs (63,209 or 42.99 percent), mainstream news (29,188 or 22.55 percent), Facebook (22,233 or 17.18 percent), and forums (7,595 or 5.87 percent). There was a noticeable spike in activity during major weather events. The top three spikes in activity occurred on January 19, 2012, following the snowstorm in Seattle with 3,840 posts, on February 3, 2012, following the snowstorm in Denver with 2,590 posts, and on March 2, 2012, following the multiple tornado outbreaks across the country with 2,077 posts (see figure 1). Radian6 software allows us to identify and extract public conversations around specific events, dates, and locations that are discussed via social media [2].

We also created several conversation clouds based on the most frequently used words found in actual posts used to describe natural disasters and weather-related events during the winter of 2011-2012. Conversation clouds surface the most frequently appearing terms used in social media posts to describe a weather event, a location, or an issue. They are built by analyzing raw word counts that appear within a set of social media posts that appeared during a user-specified period of time. Figure 2 is a conversation cloud from January 19, 2012, following the snowstorm in Seattle. The larger the word, the more frequently it was used.

Figure 2. Seattle Conversation Cloud

Figure 3 presents the conversation cloud resulting from a blizzard in Denver, Colorado during early February. There were 3,754 posts about the blizzard that spanned conversations about attending social

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2 Based on the Emergency Response Profile

3 I selected Facebook, MySpace, Images, Videos, Mainstream News, Blogs and Forums.
events, the implications of the blizzard for personal lives, and travel disruptions.

Figure 3. Denver Conversation Cloud

Figure 4 depicts the conversation cloud from March 2, 2012, following the multiple tornado outbreaks across the country. It is important to note these conversations captured not only the weather event, but also provide a sense of the locations, where the weather events occurred. There were 2,077 social media posts in numerous cities across the country.

Figure 4. Tornado Conversation Cloud

Our analysis of social conversations within the Radian6 platform yielded several touch points for managers regarding sources and forms of content that appeared in social media.

Sources of Posts: Our analysis provided three important touch points relevant to emergency management and social media.

1. Traditional Information Sources - Traditional news and weather services exerted a strong, persistent influence on the conversations around weather across time and space. In every conversation, we found that sources of tweets or reports on weather such as the local news, national news, and the national weather service helped to initiate and support the dialogue about the event, the impact of the event, and the implications of the event. Most frequently, we found that information provided by traditional news and weather services were “retweeted” and “reposted” by social media users seeking to make their acquaintances aware of the pending or current weather event. While social media may offer another forum for communicating about weather events, this finding underscores the importance of emergency managers maintaining relationships with, and working with, well-established weather sources.

2. Location of Posts – Social media users frequently commented on weather occurring in other locations around the globe. Our analysis of social media content revealed that individuals whose profiles indicated that they were in a different location or who used language that implied the comment was about severe weather in another location often created tweets and posts about unusual weather. For example, a user in Buffalo, New York might comment on severe weather in Seattle, Washington. While it may not be surprising for individuals to comment on unusual events in other locations, this finding underscores the difficulty of teasing out actionable, location-specific posts relevant to emergency management from the broader social media conversation about a weather event. Because the majority of social media posts, or platforms, do not offer managers sufficient information on user location, social media listening may have limited utility for managers seeking to allocate resources.

3. Emergency Management and Posts – While we identified posts to city-sponsored accounts that urged citizens to heed severe weather alerts, we found scant evidence that emergency managers used social media monitoring as a tool to identify citizens in need or to allocate resources during the Winter of 2012. Moreover, we did not find evidence that municipal and county governments were pro-actively using social media to engage with and direct emergency management teams to citizens in need. In light of point two above, this finding is not surprising. Absent high quality, reliable information on the location of a source of social media content, it is likely managers directed resources to familiar, proven techniques for managing emergency management resources.
Forms of Content: Our analysis provides useful insight into the forms of content that social media users were likely to direct attention to or to share with members of their networks.

1. Alerts—We offered by a traditional information source, we found that when posts contained terms such as alert, warning, or severe weather were likely to be retweeted. More specifically, when alerts mentioned specific geographic locations such as “southside” associated with a city, citizens shared the information with their peers by “retweeting” or “liking” content. We found that such text content was relatively ephemeral, with limited persistence on social media outlets. For example, a tweet that a severe weather alert has been issued can disappear from an active Twitter user’s stream within minutes. For emergency managers, this underscores the importance of a) using concise language, which attracts users’ attention and b) repeating the message on social media platforms.

2. Images—We found that social media content was shared when users, be they a traditional information source or individual, posted a picture of a location or event in progress. Pictures of tornados, flooding, or lightning drew attention and were extensively circulated within platforms such as Twitter as well as across platforms such as Twitter and Facebook. For example, a social media user posted a warning of flooding on a city street. That picture was reposted on Twitter, Facebook, and in other outlets over the course of the next several days. Many of the reposts encouraged viewers to proceed with caution or to avoid the affected area. For emergency managers, this finding confirms findings found in industry-based research that suggests images are likely to draw attention and encourage awareness of a brand or event. It goes beyond industry based research in that it suggests consumers will issue calls to act for action in context appropriate ways, when discussing a potentially dangerous situation.

4.3 Study 3: Semantic Analysis and Survey

Having listened to the “social conversation,” we next designed an analytics study based on the data collected in Study 2. Using Leximancer, text analytics software, we: 1) determined the related themes and concepts in the data set and 2) identified the unique and overlapping concepts and themes for particular cities [10]. Leximancer has been utilized in many disciplines to extract themes from unstructured natural language text [11]. Our analysis describes the corpus of text by visually representing the data (e.g., a concept map) and developing a likelihood model. This concept map is derived by the software by doing the following: 1) using Bayesian statistics to develop families of words into thesaurus (seed) concepts; 2) using machine learning to iteratively grow a thesaurus of works around the initial seed concepts; 3) then using these seed concepts to classify the text to concepts by evaluating the posts; 4) developing a network diagram of related concepts; and 5) creating a likelihood model for concepts appearing in certain groups. The connections between the concepts within the visualization are represented by a Gaussian network and can be further grouped into themes. Leximancer is different from other data mining tools, as it is based on a Bayesian co-occurrence metric for semantic analysis that allows concepts to be classified from small text segments. Smith and Humphreys (2006), who pioneered natural language text mining, described the process of using the algorithm to find and differentiate concepts as follows:

To characterize the identity of a concept such as dog in this text, terms such as bark, kennel, and tail may be diagnostic, in that those terms may appear frequently alongside dog and infrequently elsewhere. Note that in other documents, bark could be diagnostic of trees. However, the term postman, although it may appear in relational encounters with dog, will occur more often elsewhere in other relationships. Thus, it seems appropriate to consider postman and dog as separate categories in this text, with the category of dog being discriminated by such words as bark, kennel, and tail. (p. 264).

Once the concepts are distinguished (e.g., live in a town, not live newscast on television), they are grouped into themes, which identify closely related concepts using a bootstrapped Bayesian decision analysis. Further, we can analyze any similarities and differences between categories (e.g., in this case the different cities); this is comparable to what a Venn diagram of the concepts that mention each of the cities. Then the statistical likelihood models are calculated for each city. These models indicate the likelihood of a particular concept existing in a given city. For example, one may have a concept, say “cold” that occurs 167 times in the New York City data and has a likelihood of 16 percent in the data in general. This means that 16 percent of the text segments in New York City contain “cold” concepts (e.g., concepts like cool, chilly, and so on). The
statistical likelihood gives the conditional probability for a concept to be included in a particular category [11; e.g., a certain journal]. A bootstrapped process is used to calculate the likelihood ratios. There were 127,713 Concept Blocks calculated from the data set with 48 total Concepts extracted into six categories.

4.3.1. Semantic Analysis Results
There are several signals one should look for when understanding these semantic visualization maps. First, many words are populated throughout the figure and attached to nodes (e.g., very small dots). These concept nodes are calculated through the previously mentioned procedure from statistically relating words in the data. All of the relevant concept nodes (e.g., likelihood greater than zero percent) are shown in the visualization (see Figure 5). Next, these concept nodes are grouped by circles. These circles, which encompass the concept nodes, are called themes. The themes are calculated by the same procedure as the concept nodes. Themes relate the concepts to each other so that inferences can be made. Note the links between concepts (e.g., lines). These links from the concept nodes represent the likelihood of the concepts being mentioned together. Finally, the spatial representations demonstrate the relationships between the themes and the groups.

Figure six provides the visualization of the themes and concepts and Table 1 provides the likelihood models for the themes in the corpus of the social message posts. We include a category node to represent the different cities, therefore allowing us to compare the interrelated concepts and themes (e.g., at the center of the visualization) and those concepts and themes at the periphery.

To evaluate the data mining output, with all six cities, we examine the visualization first (see Figure 6). From this we can see that each of the cities has commonalities in the center (e.g., “watch,” “evening,” and “cold”), but they also provide distinct concepts that have been extracted from the social media posts. Figure seven illustrates the role of spatial representation in the visualization. For example, the distance between the “fog” concepts and other related concepts — “morning” has a high likelihood so it is close to the fog node, whereas “power” has a lower likelihood so it is farther from the “fog” node. Figure seven depicts a screen shot indicating the relationship between “fog” and each of the concepts and the related likelihood model.

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<thead>
<tr>
<th>Theme</th>
<th>Relevance Likelihood</th>
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<tr>
<td>snow</td>
<td>100%</td>
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<tr>
<td>weather</td>
<td>26%</td>
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<tr>
<td>storm</td>
<td>20%</td>
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<tr>
<td>rain</td>
<td>16%</td>
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<td>winter</td>
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<td>fog</td>
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4.4. Study 4: Survey on Social Media Outlet
Finally, we conducted a survey that asked active social media users, who had commented on weather events, to identify the social media outlets they used when seeking emergency management information. To inform our understanding of how to craft emergency management strategies, we conducted a
survey of active social media users who participated in the discourse around severe weather on Twitter.

Using the search queries described in Phase two, we identified a population of social media users who actively discuss severe weather. We focused our attention on two sample populations. First, we sampled from social media users who discussed tornadoes and flooding. We did so, because these are frequent, unexpected weather events. Given that social media is a means to quickly reach citizens, we felt that this provided a useful context for evaluating which social media platforms citizens monitored to collect information on severe weather. From our sample of social media posts, we invited social media users who had discussed tornadoes on March 2nd on Twitter to participate in the survey. Second, we sampled from a more general population of social media users at a major University in the Southern United States. We felt that this provided balance to our survey, as young, college students are frequent users of social media. We obtained responses from 238 social media users. 56% of the participants were male. 70% of the sample was between 18 – 24 years old.

4.4.1. Survey Results
Seventy-three percent of the participants believe that social media should be used in an emergency. However, only 42 percent of the participants expect their municipality to “listen” to social media. 8 percent of the participants have posted information on a social media site during a natural disaster in their city. Yet, only 1 percent received a reply from a city or state government representative.

<table>
<thead>
<tr>
<th>Social Media Position</th>
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<tr>
<td>%</td>
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<tr>
<td>Believe that social media should be used in an emergency.</td>
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<tr>
<td>Expect their municipality to “listen” to social media.</td>
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<tr>
<td>Have posted information on a social media site during a natural disaster.</td>
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<tr>
<td>Received a reply from a city or state government representative.</td>
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This confirmed our finding in Phase two, that emergency managers were not using social media to respond to citizens. Based on the results of our survey, our participants rely on Facebook, Twitter, and Google+ to receive and disseminate information during an emergency. In addition to the six social media tools that we assessed, participants indicated that they also use cell phone apps, the local news, and fwxnewyork.com.

5. Discussion
We conducted multi-study and multi-method line of inquiry of social media utilization for crisis management. Currently, social media use for emergency response management is in its infancy. We found little evidence that government agencies were listening to social media comments during the winter of 2012 and even less evidence of agencies using social media to respond to these comments. While municipalities were not systematically taking advantage of using social, we did find evidence that citizens use social media to report, comment, and share information during natural disasters. Across cities, we found commonalities in citizen driven platforms for discussing weather (e.g., Facebook and Twitter), patterns of use (e.g., topics discussed and interest in images) and language used to describe the weather events during the winter of 2012.

Based on our analysis, we can forward several recommendations for managers of cities – irrespective of size – for communicating with citizens before, during, and after emergencies.

Finding One: Content Creation
Our analysis found that citizen conversations’ about weather-related events were often primed by one of two types of content – news reports and eyewitness pictures. Overwhelmingly, we found that subscribers to traditional media and government funded information sources were the first to “tweet and retweet” information on weather. In parallel, we found that citizens were apt to snap “action shots” of flooding, snow, or emergency responders and share them with their friends and followers. Our finding on conversations has important implications for city managers seeking to promote their social media presence. First, where mimicry is considered bad form in traditional media, retweeting or reposting information is an accepted form of content creation in social media outlets. We encourage city managers to look to conventional print, radio, television, and government information sources to generate locally relevant emergency management content. Second, when creating content, it is important for city managers to understand the value of incorporating authentic, citizen-created posts and images. By scanning Twitter, Facebook, Instagram and other platforms for a) context specific images (e.g., flooding on a city street) or b) conversations about emergency service provision, employees can provide
an authentic view of the impact of weather events and emergency responders in the community.

Finding Two: Hashtags
While not all weather events may be anticipated, with reasonable frequency, major disasters such as hurricanes and storm systems are forecast by the national weather service. We found that nearly every major weather event was preceded by a posting from major media and government information sources. To enable communicating with citizens, we encourage city managers to consider employing aggressive “hashtag” strategies. Hashtags (a hashtag is a word within a message prefixed by a hash sign) are a means for emergency responders and citizens to identify the broad theme or content of a message. By creating and promoting a hashtag in a timely manner, city managers will provide citizens with information necessary to a) make identifying comments, pictures, or even pleas for help more readily, and b) enable responding to those comments by citizens. In order to facilitate timely creation of hashtags, managers must create partnerships among a) agencies who provide emergency responses, b) sources of media/weather information, and c) employees assigned to manage social media. Presently, we see hashtags emerge during events such as Hurricane Sandy, we believe that a creating processes that ensure the timely creation and promotion of a hashtag will make it easier for managers to use social media to manage the event.

Finding Three: Investing in Social Media
Across all aspects of our study, aggregation and analysis of social media content, we found evidence that citizens are increasingly turning to social media for information on weather-related event and that they expect government agencies to provide such content. While social media may appear simple, e.g., a tweet is only 140 characters, learning how to effectively manage social media requires a large investment in time and resources. To do so effectively, we believe city managers need to at a minimum take the following steps: assign a person or team to manage social media during an emergency; prepare to invest resources; evaluate their audience and context; and learn their citizens’ language.

Through allocating resources, preparing adequately and establishing clear expectations about social media use, city managers have an opportunity to more effectively deliver services during weather-related incidents. On the contrary, the absence of a social media strategy may make agencies appear out of touch or unresponsive to citizen’s needs.

6. Conclusion
This field is constantly evolving. There are many opportunities for future research. For instance, future studies should explore the following question: During an emergency do people prefer emotional support from their peers (other citizens) or official information from government agencies? As more agencies begin to implement social media listening strategies, the need for effective evaluation will increase. How do you close the feedback loop? How do you evaluate the effectiveness of your social media strategy? Who is responsible for social media management? Organizations need a blueprint that identifies how they will implement and evaluate social media response during a disaster. Government agencies should consider using the services of a social media listening firm, such as Radian6 or BrandWatch, as a part of a comprehensive social media listening strategy.

7. References


