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TWITUATIONAL AWARENESS: GAINING SITUATIONAL AWARENESS VIA CROWDSOURCED #DISASTER EPIDEMIOLOGY

by

Daniel T. Cain

September 2013

Thesis Co-Advisors: Robert Josefek
Lauren Fernandez

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13. ABSTRACT (maximum 200 words)

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TWITUATIONAL AWARENESS: GAINING SITUATIONAL AWARENESS VIA CROWDSOURCED #DISASTER EPIDEMIOLOGY

Daniel T. Cain
Senior Industrial Hygienist, Oregon Health Authority, Portland, OR
B.S., Illinois State University, 1994

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September 2013**

Author: Daniel T. Cain

Approved by: Robert Josefek
Thesis Co-Advisor

Lauren Fernandez
Thesis Co-Advisor

Mohammed Hafez
Chair, Department of National Security Affairs

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ABSTRACT

Public health and other agencies need situational awareness to respond effectively to disasters or other incidents. Traditional means of obtaining this information require significant time and personnel. Social media is becoming increasingly popular among American citizens, and research is demonstrating that it may be a useful tool for bolstering information about unfolding events. This research analyzed the potential of the microblogging service Twitter in providing situational awareness. Tweets from a major snowstorm affecting the state of Massachusetts were collected, coded for content, and compared to traditional public health methods. The results indicate that Twitter can provide a rich source of data for responding agencies. Still, the immense volume of conversations makes extracting useful information in a timely manner a significant challenge. Practical approaches uncovered during this research can help agencies with nascent social media surveillance programs begin to unearth the valuable information that Twitter contains. Collaboration with information technology experts could allow public health and other responding agencies to create even greater value from social media platforms.

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LIST OF ACRONYMS AND ABBREVIATIONS

CASPER	Community Assessment for Public Health Emergency Response
CDC	The Centers for Disease Control and Prevention
HIPAA	Health Insurance Portability and Accountability Act
MBTA	Massachusetts Bay Transportation Authority
MT	Modified Tweet
NRF	National Response Framework
PFA	Psychological first aid
QPS	The Queensland Police Service
RNA	Rapid Needs Assessments
The Guide	Psychological First Aid Field Operations Guide
WNV	West Nile Virus

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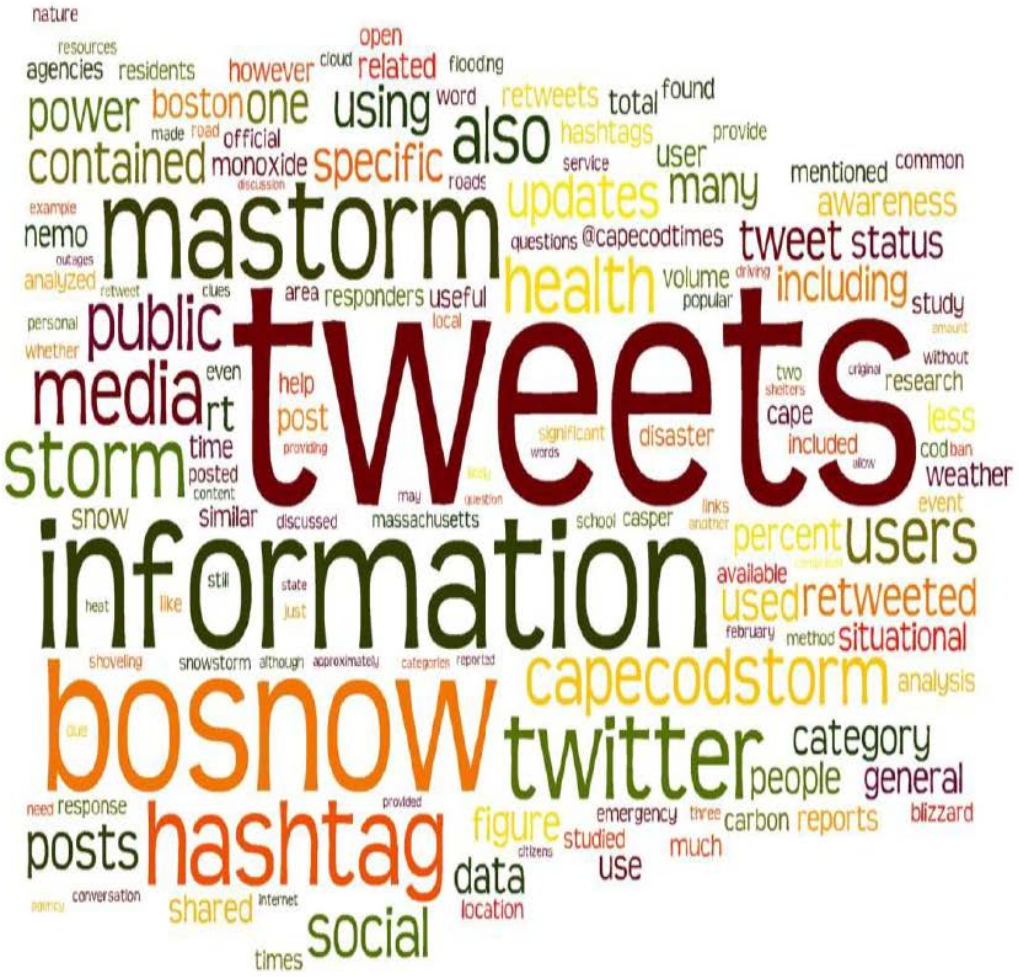
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EXECUTIVE SUMMARY

Public health and other agencies need situational awareness to respond effectively to disasters or other incidents. This information allows responders to improve their response, target neglected areas, and learn from mistakes. Traditional means of obtaining this information, such as rapid needs assessments, require significant time and personnel. The CDC suggests 20 to 30 people are needed for their rapid needs assessment, the Community Assessment for Public Health Emergency Response (CASPER).

Social media is becoming increasingly popular among American citizens, and allows people to provide information about every aspect of their lives. Research is demonstrating that it may be a useful tool for bolstering information about unfolding events. This research analyzed the potential of the microblogging service Twitter in providing situational awareness. Twitter posts are attractive because tweets are visible to everyone, not just friends of the poster. The 140-character limit imposed by Twitter encourages brevity. The number of people using Twitter has more than quadrupled since 2010, so the platform is becoming increasingly popular.

Tweets from a major snowstorm affecting the state of Massachusetts were collected, coded for content, and compared to traditional public health methods of intelligence gathering. Data from three separate hashtags were analyzed to see how content varied depending on the hashtag used. The results indicate that Twitter can provide a rich source of data for responding agencies. Users posted information about the impact of the storm, needed resources, and their own well-being. This information could be used by responders to improve future responses. Much of the information sought by a tool such as CASPER was available from tweets studied in this research.

Still, the immense volume of conversations makes extracting useful information in a timely manner a significant challenge. Practical approaches uncovered during this research can help agencies with nascent social media surveillance programs begin to unearth the valuable information that Twitter contains. Agencies can initiate social media

surveillance without any additional resources. Collaboration with information technology experts could allow public health and other responding agencies to create even greater value from social media platforms.

ACKNOWLEDGMENTS

This research could not have been completed without the support of my incredible family. My beautiful wife, Catherine, has been there to assist me every step of this journey. Whenever I felt as if I could not go any further, her constant support reminded me that I could never repay the sacrifices I have asked of her without delivering a completed thesis. She is the love of my life, and a true inspiration. My daughters, Shayla, Ashley, and Hailey, have been patient and understanding of all the time I was not around while completing this project. I hope that I could at least serve as a role model for their own studies. Our three dogs, Jackson, Elly, and Gribble, offered a warm heart and a cold nose to help reduce my stress levels.

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Finally, but in no way last, I dedicate this thesis to my father, Ron. I hope I would have made you proud, and if I am ever half the man you were, I will have accomplished something extraordinary.

I. INTRODUCTION AND LITERATURE REVIEW

A. PROBLEM SPACE

In the aftermath of disasters, often disruptions and illnesses occur that threaten the public health. Considered the basic science of public health, epidemiology is the study of disease (and absence of it) and all the factors that influence it.[1] Public health responders use epidemiology to enhance situational awareness during incidents, also known as disaster epidemiology. Disaster epidemiologists have traditionally used Rapid Needs Assessments (RNA) to assess the impact of a disaster on the population, determine the health needs, and evaluate the effectiveness of relief efforts. Ultimately, these efforts are credited with reducing mortality for current disasters, as compared to those from the past, by making the population more resilient.

Given the nature of emergencies, it is important that data be collected quickly. Some data becomes either impossible to collect later (e.g., quality of onsite care), or is useless to decision makers (e.g., ill patients die before treatment can be given). The Centers for Disease Control and Prevention (CDC) created a tool for disaster epidemiologists known as Community Assessment for Public Health Emergency Response (CASPER). It is designed to be implemented within 72 hours following the decision to collect data to ensure that the data collected is timely and useful. Completing a CASPER is time consuming and requires significant staff support.

Among the information required by incident managers, vulnerable population data is critical. As emergencies vary by type, so too do the populations most vulnerable to a specific disaster. Thus, disaster epidemiology helps identify these populations that require particular assistance from responders. Community assessments, such as CASPER, can also help responding agencies identify issues not previously recognized or may be

[1] U.S. Department of Health and Human Services, National Institute of Health, National Institute of Deafness and Other Communication Disorders (NIDCD), "What Is Epidemiology?," (n.d.), https://www.nidcd.nih.gov/health/statistics/Pages/epidemiology.aspx.

emerging. Agencies can use these assessments to target populations most in need of assistance, and determine which, if any, community needs have already been met.[2]

To analyze an affected community, significant human capital is required to complete a CASPER. The CDC estimates that 20–30 interviewers are needed.[3] With public health funding shrinking, even less resources are available for this labor-intensive activity.[4] Given the significant amount of resources a CASPER requires, it is unsurprising that the Oregon Public Health Division has never actually performed one. While CASPER is a well-designed tool that provides useful results, it requires too much time, personnel, and coordination for use during emergencies. A well-designed process is not useful to responders without the resources to put it into action. Public health responders need a quicker, less labor-intensive method to gain situational awareness.

Social media offers a compelling opportunity to bolster situational awareness with information similar to that collected by a CASPER by tapping into conversations happening on the Internet. Twitter is a microblogging application that allows users to post status updates or comments of up to 140 characters. An advantage of Twitter over other types of social media is that messages are mostly public, and can be viewed by anyone.[5] Pew Internet research suggests that the adoption of Twitter is rapidly increasing, with the number of users who access Twitter daily doubling since 2011, and quadrupling since 2010. The report notes that approximately 15% of adult Internet users are also Twitter users, and 8% of adult Internet users report using Twitter daily. In June 2012, Twitter

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[2] Texas Department of State Health Services, "Community Assessment for Public Health Emergency Response (CASPER)," (n.d.), http://www.dshs.state.tx.us/commprep/disasterepi/casper/intro.aspx.

[3] Tesfaye Sanchez Bayleyegn, National Center for Environmental Health (U. S.), and Division of Environmental Hazards and Health Effects, *Community Assessment for Public Health Emergency Response (CASPER) Toolkit Hausman, Leslie* (Atlanta, GA: Centers for Disease Control and Prevention, National Center for Environmental Health, Division of Environmental Hazards and Health Effects, Health Studies Branch, 2009).

[4] Emergency Management, "Funding Cuts Threaten Public Health Preparedness," (n.d.), http://www.emergencymgmt.com/health/Funding-Cuts-Threaten-Public-Health.html.

[5] F. M. Bhat, K. Challis Oussalah, and T. Schnier, "A Software System for Data Mining with Twitter," in *2011 IEEE 10th International Conference on Cybernetic Intelligent Systems (CIS)*, 2011, 139–144.

CEO Dick Costolo reported that users are now tweeting 400 million posts per day. A growing body of literature suggests that Twitter does provide valuable information during emergencies that could be useful for incident managers and responders.[6,7,8]

A significant barrier to incorporating Twitter into the public health response is the volume of Tweets. Previous research has investigated automated tools to process and analyze Tweets, by filtering out irrelevant information, and by allowing researchers to more easily find the critical information. At the moment, an off–the-shelf solution is not available. Current methods employed by the Oregon Public Health Division involve staff manually entering and reviewing Twitter searches. This method is time-consuming, challenging, and results in the division only having a general sense of what is being discussed on Twitter.

B. RESEARCH QUESTION

Public health agencies face shrinking budgets, and traditional methods of gaining situational awareness are resource intensive. Can social media be used to provide situational awareness to public health and other responders during an emergency? If social media can provide situational awareness, how can a public health agency leverage this technology with limited financial and human resources?

C. LITERATURE REVIEW

Twitter was launched in July 2006.[9] Other social media websites are also new, and a growing body of research has emerged on how to use social media to improve

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[6] Axel Bruns et al., "#qldfloods and @QPSMedia: Crisis Communication on Twitter in the 2011 South East Queensland Floods," Report, *ARC Centre of Excellence for Creative Industries and Innovation; Creative Industries Faculty; Institute for Creative Industries and Innovation; Journalism, Media & Communication,* January 10, 2012, http://eprints.qut.edu.au/48241/.

[7] Axel Bruns and Jean E. Burgess, "Local and Global Responses to Disaster: #eqnz and the Christchurch Earthquake," Conference Paper, *Disaster and Emergency Management Conference, Conference Proceedings*, 2012, http://anzdmc.com.au/proceedings.pdf.

[8] Cheng-Min Huang, Edward Chan, and Adnan A. Hyder, "Web 2.0 and Internet Social Networking: A New Tool for Disaster Management?—Lessons from Taiwan," *BMC Medical Informatics and Decision Making* 10, no. 1 (October 6, 2010): 57. doi:10.1186/1472–6947–10–57.

[9] Business Insider, "The Real History of Twitter," April 13, 2011, http://www.businessinsider.com/how-twitter-was-founded-2011–4.

disaster response and recovery.[10,11,12] Themes in the literature are evaluations of the utility of Twitter and social media for providing situational awareness, case studies in which social media was successfully used during disasters, social media as an indicator of disease, literature about how information spreads on social media, and reports of available tools to enhance social media awareness.

Note: this thesis makes extensive reference to the use of hashtags, beginning in the literature review. Hashtags are used in Twitter to organize discussions, and make it easier to find items of interest. Hashtags are identified using the # symbol. Hashtags are not controlled by employees at Twitter, but are added by end users as a way to flag their posts. At the beginning of an event of interest to users of Twitter, competing hashtags may be used, but users appear to settle on a winner in an organic, evolving manner.[13]

1. Evaluation of Twitter/Social Media for Potential to Enhance Situational Awareness

Research shows that information available on Twitter and other social networks could provide very important clues for emergency managers, including additional sources of information, and public reaction to official response efforts.[14,15] Birregah et al. proposed a method for systematically processing tweets based on their content (URL link, picture, text, hashtag, and reference to others) to help manage the vast flow of

[10] Queensland University of Technology, "#qldfloods and @QPSMedia: Crisis Communication on Twitter in the 2011 South East Queensland Floods | QUT ePrints," January 24, 2012, http://eprints.qut.edu.au/48241/.

[11] Bruns and Burgess, "Local and Global Responses to Disaster: #eqnz and the Christchurch Earthquake."

[12] Huang, Chan, and. Hyder, "Web 2.0 and Internet Social Networking: A New Tool for Disaster Management?—Lessons from Taiwan," 57.

[13] Cat's Pyjamas, "Social Media Use in a Crisis–#eqnz–Which Hashtag Prevails?" September 4, 2010, http://www.cats-pyjamas.net/2010/09/social-media-use-in-a-crisis-eqnz-which-hashtag-prevails/.

[14] Jiang Zhu et al., "Statistically Modeling the Effectiveness of Disaster Information in Social Media," in *2011 IEEE Global Humanitarian Technology Conference (GHTC)*, 2011, 431–436.

[15] O. Aulov and M. Halem, "Human Sensor Networks for Improved Modeling of Natural Disasters," *Proceedings of the IEEE* PP, no. 99 (2012): 1–12.

information over social media.[16] A study of Twitter data in New Zealand that analyzed approximately 66 million tweets, found abundant useful information for emergency managers contained in the social media reports and proposed a method for New Zealand officials to use Twitter to detect emerging incidents.[17] Analysis of similar Twitter data showed a wealth of information about the Japan earthquake and tsunami of 2011.[18] These studies also explore whether tweets are a reliable source of information. Although the research was related to influenza detection, Chow found very little misinformation in a study of over three million tweets. Gao et al. noted that while the crowdsourcing system Ushahidi (described below) allows users to verify reports made by other parties, more research needs to be done to determine a better method to prevent false reports.[19] However, Liu et al. identified several methods that researchers should explore to verify the accuracy of self reporting, including comparison to more traditional data acquisition methods.[20] The Queensland Police Service (QPS) of Australia successfully addressed misinformation by directly countering it on Twitter, and denoting it with the hashtag #Mythbusters.[21]

Studies of this nature also explore whether geocoded location data offers information useful to incident managers for situational awareness. Users can allow Twitter to attach geocoded data to tweets, which can be invaluable for mapping disaster impacts. MacEachren et al. found useful data on relief supplies and spontaneous fund

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[16] Babiga Birregah et al., "Multi-layer Crisis Mapping: A Social Media-Based Approach," in *2012 IEEE 21st International Workshop on Enabling Technologies: Infrastructure for Collaborative Enterprises (WETICE)*, 2012, 379–384.

[17] J. Yin, A. Lampert, M. Cameron, B. Robinson, and R. Power, "Using Social Media to Enhance Emergency Situation Awareness," *IEEE Intelligent Systems* PP, no. 99 (2012): 1.

[18] Yusuke Nakaji and Keiji Yanai, "Visualization of Real-World Events with Geotagged Tweet Photos," in *2012 IEEE International Conference on Multimedia and Expo Workshops (ICMEW)*, 2012, 272–277.

[19] Huiji Gao, G. Barbier, and R. Goolsby, "Harnessing the Crowdsourcing Power of Social Media for Disaster Relief," *IEEE Intelligent Systems* 26, no. 3 (June 2011): 10–14.

[20] Yong Liu, Pratch Piyawongwisal, Sahil Handa, Liang Yu, Yan Xu, and Arjmand Samuel, "Going Beyond Citizen Data Collection with Mapster: A Mobile+Cloud Real-Time Citizen Science Experiment," in *2011 IEEE Seventh International Conference on e-Science Workshops (eScienceW)*, 2011, 1–6.

[21] Queensland University of Technology, "#qldfloods and @QPSMedia: Crisis Communication on Twitter in the 2011 South East Queensland Floods | QUT ePrints."

raising for relief efforts.[22] However, a valid concern has been raised that not all data will be accurate. Users could send their reports from a different location than the actual area being reported on, perhaps waiting until they are in a safer location to send a tweet, which could confuse responders and result in misdirected resources.[23]

A limitation of the use of Twitter is that the demographic age of Twitter users heavily favors the 25–54 age range.[24] Responders will need to be cognizant that Twitter data may not be representative of the entire population during a disaster. However, a survey conducted by the American Red Cross found that many social media users turn to those applications in an emergency, and they are likely to follow advice given through social media platforms.[25] Thus, by ignoring social media, agencies could miss a chance to engage with people who primarily get information through those channels.

Reports from the Haiti earthquake indicate that many of even the most poverty-stricken populations were able to provide data on their situations using the Ushahidi text messaging system.[26] An advantage of this text messaging system is that it does not require a smart phone or a Twitter account; therefore, it is available to a larger portion of the population. As of March 2012, Nielson reports that only 50% of United States (U.S.) cell phone users have smartphones, although this usage is a rapidly increasing trend.[27] In contrast, evidence exists that social media can actually enhance the ability for public health departments to interact with populations that have traditionally been difficult to reach, including rural or isolated people, and those suffering from a disease associated

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[22] A. M. MacEachren et al., "SensePlace2: GeoTwitter Analytics Support for Situational Awareness," in *2011 IEEE Conference on Visual Analytics Science and Technology (VAST)*, 2011, 181–190.

[23] Gao, Barbier, and Goolsby, "Harnessing the Crowdsourcing Power of Social Media for Disaster Relief."

[24] MacEachren et al., "SensePlace2: GeoTwitter Analytics Support for Situational Awareness," 181–190.

[25] American Red Cross, "More Americans Using Mobile Apps in Emergencies," August 31, 2012, http://www.redcross.org/news/press-release/More-Americans-Using-Mobile-Apps-in-Emergencies.

[26] Jessica Heinzelman and United States Institute of Peace, *Crowdsourcing Crisis Information in Disaster-affected Haiti Waters, Carol*, Special Report, 252; Variation: Special Report (Washington, DC: U.S. Institute of Peace, 2010), 252.

[27] Nielsen Wire, "Smartphones Account for Half of All Mobile Phones, Dominate New Phone Purchases in the U.S.," (n.d.), http://blog.nielsen.com/nielsenwire/online_mobile/smartphones-account-for-half-of-all-mobile-phones-dominate-new-phone-purchases-in-the-us/.

with social stigma (e.g., depression sufferers).[28] Another study showed potential for social media to enable effective surveillance for areas with limited resources, as the technology can be implemented at lower cost than traditional methods.[29]

2. Studies of Successful Use of Social Media During Emergencies

A number of incidents have occurred in which Twitter and other microblogging technologies were used to enhance situational awareness during an incident. Much of this literature relates to disaster management activities outside the public health response, but many, if not the majority of disasters, threaten public health.[30] Van Leuven analyzed the use of social media during the 2007 southern California wildfires, and found that private groups were able to harness the technology successfully to provide actionable intelligence for citizens.[31] The crowdsourcing system called Ushahidi was used successfully to provide situational awareness during the 2010 Haiti earthquake, and the 2011 Japan earthquake and tsunami.[32] In addition to sorting data from Twitter, Ushahidi can utilize data from other social media, such as Facebook. An even more compelling feature very successful in Haiti was accepting data in Ushahidi using text messaging from cell phones. While the earthquake destroyed the majority of the cell towers in Haiti, many were quickly repaired. The free text messaging hotline allowed self-reporting on conditions that allowed responders to direct aid more effectively.[33] An advantage of both

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[28] Rebecca Keelan Schein, Peel (Ont.), and Peel Public Health, *Literature Review on Effectiveness of the Use of Social Media a Report for Peel Public Health / Wilson, Kumanan* (Brampton, Ont.: Region of Peel], Peel Public Health, Saint-Lazare, Quebec: Canadian Electronic Library, 2011).

[29] Jonathan Cinnamon and Nadine Schuurman, "Injury Surveillance in Low-resource Settings Using Geospatial and Social Web Technologies," *International Journal of Health Geographics* 9, no. 1 (May 24, 2010): 25, doi:10.1186/1476–072X-9–25.

[30] Kimberley I., Shoaf and Steven J. Rottman, "Public Health Impact of Disasters," *Australian Journal of Emergency Management* 15, no. 3 (2000): 58–62.

[31] Laurie J. Van Leuven, "Optimizing Citizen Engagement during Emergencies through Use of Web 2.0 Technologies," *DTIC Online*, March 2009, http://stinet.dtic.mil/oai/oai?&verb=getRecord&metadataPrefix=html&identifier=ADA497269.

[32] Huiji, Barbier, and Goolsby, "Harnessing the Crowdsourcing Power of Social Media for Disaster Relief," 10–14.

[33] Jessica Heinzelman and Carol Waters, United States Institute of Peace, *Crowdsourcing Crisis Information in Disaster-affected Haiti*, Variation: Special Report, October 2010.

text messaging and Twitter is that the low bandwidth of a short message will often be delivered on an overloaded or damaged cell network, while a phone call may not.[34]

The Queensland Police Service (QPS) recently established itself as a leader among public safety agencies in harnessing the effective use of social media; Twitter, in particular, to enhance their emergency response efforts. As the lead responding agency for massive flooding in 2010–2011, QPS used social media effectively to improve their response. In a matter of days, the media was relying on QPS as a key source of information, including displaying QPS tweets on their news crawlers, and referring the public to the QPS social media accounts for the most up-to-date information. Posts by QPS to social media were extremely focused on providing advice and situational awareness to the public, and QPS often responded to individual requests for information. It provided 24/7 staffing to moderate the QPS social media accounts, and became a clearinghouse for all flood related information. QPS even went so far as to post information originating from other departments and agencies. Twitter users responded warmly to QPS efforts, and retweeted QPS posts at a very high rate. These retweets significantly amplified the messages being sent by the police service, which enabled them to reach Twitter users far outside their sphere of influence.[35]

3. Social Media as an Indicator of Disease Outbreaks

A third genre of literature explored how Twitter can be used to track disease outbreaks, which is also important during emergencies, as diseases, such as cholera, can spread after a disaster. Traditional epidemiology relies on hospital discharge records, so data on emerging outbreaks can take two weeks for information to reach public health officials from sentinel physician networks.[36] An early study by Eysenbach showed that web searches related to influenza keywords was highly correlated to epidemiological

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[34] ProQuest, "Web 2.0 Emergency Applications: How Useful Can Twitter Be For Emergency Response?" (n.d.), http://search.proquest.com.libproxy.nps.edu/docview/203667040/1390C6822A774753B01/8?accountid=12702.

[35] Queensland University of Technology, "#qldfloods and @QPSMedia: Crisis Communication on Twitter in the 2011 South East Queensland Floods | QUT ePrints."

[36] Nigel Collier, Nguyen Son, and Ngoc Nguyen, "OMG U Got Flu? Analysis of Shared Health Messages for Bio-surveillance," *Journal of Biomedical Semantics* 2, no. Suppl 5 (2011): S9.

surveillance data, and could be significantly less costly than traditional methods.[37] In fact, Google now collects and presents user search data related to influenza, with its Google Flu Trends product.[38] The Preparedness Surveillance Epidemiology Team of the Oregon Public Health Division is now evaluating this tool as a secondary indicator of influenza conditions in the state, although it is not expected to replace traditional surveillance.[39] Along the same line, analysis of two years of Twitter data showed a very high correlation between tweets about influenza-like symptoms and traditional influenza surveillance data.[40] Lampos and Cristianini had similar successful findings, additionally noting that their system of analyzing tweets could be expanded to all languages, which supports public health efforts to reach all populations in a jurisdiction.[41] Corley et al. also demonstrated that blog posts related to influenza were highly correlated to current epidemiological methods.[42] Social media appears to have the potential to revolutionize public health disease surveillance, particularly due to the potential for rapid detection. Social media allows individuals to report on their symptoms before they even decide to seek treatment, but several hurdles must be cleared to truly unlock this technology.[43] In particular, it is a nearly overwhelming challenge to sift through the approximately 400 million tweets per day to find useful information,[44] which echoes a common roadblock to implementing a social media plan cited by emergency management professionals that

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[37] Gunther Eysenbach, "Infodemiology: Tracking Flu-Related Searches on the Web for Syndromic Surveillance," *AMIA Annual Symposium Proceedings 2006* (2006): 244–248.

[38] Google, "Google Flu Trends | United States," (n.d.), http://www.google.org/flutrends/us/#U.S..

[39] Collette Young, personal communication with Preparedness Surveillance Epidemiology Team Manager, Oregon Health Authority, September 13, 2012.

[40] Harshavardhan Achrekar et al., "Predicting Flu Trends Using Twitter Data," in *2011 IEEE Conference on Computer Communications Workshops (INFOCOM WKSHPS)*, 702–707, 2011.

[41] V. Lampos and N. Cristianini, "Tracking the Flu Pandemic by Monitoring the Social Web," in *2010 2nd International Workshop on Cognitive Information Processing (CIP)*, 411–416, 2010.

[42] Courtney D. Corley et al., "Text and Structural Data Mining of Influenza Mentions in Web and Social Media," *International Journal of Environmental Research and Public Health* 7, no. 2 (February 2010): 596–615.

[43] Connie St Louis and Gozde Zorlu, "Can Twitter Predict Disease Outbreaks?" *British Medical Journal* 344, no. 7861 (June 16, 2012), http://search.proquest.com.libproxy.nps.edu/docview/1026778819/1388766D1B65F085D96/101?accountid=12702.

[44] Matt McGee, "With 400 Million Tweets Per Day, Twitter Spending 'Inordinate Resources' On Improving Content Discovery," June 7, 2012 at 2:33pm ET, http://marketingland.com/twitter-400-million-tweets-daily-improving-content-discovery-13581.

while the technology may be useful, resources to study and develop a working system are not available.[45]

4. How Information Spreads on Social Media

A number of studies evaluate how information is spread on Twitter. Public health must provide information to the public during emergencies on how to stay safe and healthy. Twitter has the potential to assist officials in providing timely and effective messages to the public, and research indicates that Twitter users tend to promote official sources of information over unofficial sources.[46] While health departments are starting to use social media to push messages to the public, they have not yet really harnessed the technology to enable two-way communications with the public and other stakeholders.[47] One problem with this slow adoption of social media by public health is that in many cases, rumors or false information can possibly be spread without being countered by accurate information from official sources.[48] QPS, during its response to flooding in 2010–2011, offers an effective model, both for engaging citizens into a dialogue, and the effectiveness of directly countering misinformation.[49]

5. Available Tools for Gaining Situational Awareness on Social Media

Some software tools for extracting situational awareness from social media already exist, but none appears ready for plug-and-play use by health departments. Infovigil, which was developed by the Centre for Global eHealth Innovation in Toronto, is described as an "infoveillance" system that gathers information from the Internet from

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[45] Van Leuven, "Optimizing Citizen Engagement during Emergencies through Use of Web 2.0 Technologies," 78, 80.

[46] M. Szomszor, P. Kostkova, and C. St. Louis, "Twitter Informatics: Tracking and Understanding Public Reaction During the 2009 Swine Flu Pandemic," in *2011 IEEE/WIC/ACM International Conference on Web Intelligence and Intelligent Agent Technology (WI-IAT)*, 2011, 1:320–323.

[47] Rosemary Thackeray et al., "Adoption and Use of Social Media Among Public Health Departments," *BMC Public Health* 12, no. 1 (March 26, 2012): 242.

[48] Schein, Peel (Ont.), and Peel Public Health, *Literature Review on Effectiveness of the Use of Social Media a Report for Peel Public Health / Wilson, Kumanan*.

[49] Bruns et al., "#qldfloods and @QPSMedia: Crisis Communication on Twitter in the 2011 South East Queensland Floods."

Twitter, blogs, websites, etc., and analyzes keywords. The system seems designed to bolster routine disease surveillance.[50]

HealthMap is a mash-up (combination of two or more Internet technologies) that searches the Internet for public health news and sorts (both automatically and manually) this information into aggregated data. Users can also submit reports. This system appears to be an attempt to provide public health news for geographic areas presented in a visual manner.[51] Biocaster is a very similar application that also presents collected information on a map.[52]

Flusurvey is a European effort to enable self-reporting of influenza symptoms to the flusurvey.org website. Users register, and then complete a survey every week. This information is collected and graphically presented.[53]

Ushahidi is an open source platform that enables crowdsourced mapping using web, email, text, and Twitter technologies. It is designed to be easily deployable to areas affected by disaster, and allows impacted communities to provide status updates. Crowdmap is a version of Ushahidi that is hosted, and does not require a web server. GeoChat (developed by InSTEDD) is another variant of the idea behind Ushahidi. Both have been successfully deployed to provide situational awareness in past disasters.[54]

Yahoo Pipes is a product that allows users to create mash-ups. Boulos et al. were graphically able to monitor for the West Nile Virus (WNV) by using Pipes to automatically fetch climate data that allowed them to predict areas prone to high WNV

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[50] Cynthia Chew, "Pandemics in the Age of Twitter: A Content Analysis of the 2009 H1N1 Outbreak," *T-Space, University of Toronto Research Repository*, December 16, 2010, https://tspace.library.utoronto.ca/handle/1807/25454, 39.

[51] Ibid.

[52] St Louis and Zorlu, "Can Twitter Predict Disease Outbreaks?"

[53] Ibid.

[54] Maged N. Kamel Boulos et al., "Crowdsourcing, Citizen Sensing and Sensor Web Technologies for Public and Environmental Health Surveillance and Crisis Management: Trends, OGC Standards and Application Examples," *International Journal of Health Geographics* 10, no. 1 (December 21, 2011): 67.

activity due to favorable weather conditions. One advantage of Pipes is that once a query is programmed, users do not have to refresh or update data manually.[55]

6. Need for Further Research

The key gap in research lies in the practical application of social media tools. An overwhelming amount of information is available on social media, but professionals could benefit from methods and tools to process and organize information efficiently so that they can make quick and effective decisions. Much of the research presented above took a large volume of data and analyzed it without the pressures and extreme time constraints that an active emergency presents.[56] Faster methods of processing data into useful intelligence are needed to provide information in a timely manner. A method that will allow a public health employee to uncover information easily based on the current needs of their agency is a focus of this research.

D. OVERVIEW OF CHAPTERS

To evaluate the utility of social media at providing situational awareness for public health and other responding agencies, this thesis evaluates how people used the micro-blogging service Twitter in the aftermath of a severe snowstorm in Massachusetts, and whether that information might be useful for public health and other responding agencies.

Chapter II discusses the method used to analyze tweets from the storm. Chapter III evaluates tweets specific to the Boston, MA metropolitan area after a significant snowstorm. Chapter IV investigates tweets from the same storm, but from a statewide perspective. Chapter V looks at tweets in the Cape Cod area from the same snowstorm. Chapter VI analyzes the three case studies as a whole, and offers recommendations for the implementation of a social media surveillance program, and items that warrant future research. The Appendix explores whether Twitter can be used to provide psychological first aid following a disaster.

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[55] Maged N. Kamel Boulos et al., "Web GIS in Practice VI: a Demo Playlist of Geo-mashups for Public Health Neogeographers," *International Journal of Health Geographics* 7, no. 1 (July 18, 2008): 38.

[56] St Louis and Zorlu, "Can Twitter Predict Disease Outbreaks?"

II. METHOD

To evaluate if social media contains situational awareness that could be valuable for responders, this thesis studies the use of Twitter following a severe weather event in Massachusetts. Tweets were collected from three hashtags (see below) during and after the storm. Tweets were then coded according to content, and analyzed to determine if they could be useful in providing situational awareness. This data was then compared to the question bank in the CDC CASPER Toolkit[57] to explore which facets of disaster epidemiology might be possible using social media. Finally, a brief word cloud demonstration is provided as way to visualize quickly some of the key subjects posted to each hashtag.

This study then takes a self-reflective approach to address the second research question on how a public health agency can use this technology with limited money and personnel. Observations acquired during the course of this research are used to recommend techniques and address remaining challenges.

A. THE EVENT

On February 8, 2013, a severe winter storm moved over the northeastern United States and dumped a significant snowfall around the region. According to an article by The Weather Channel, Boston, MA experienced the fifth largest snow accumulation in city history.[58] This event provided an excellent opportunity to study how residents of Massachusetts used Twitter to interact with each other while dealing with the effects of the storm, and evaluate if those conversations could be valuable for public health and other responding agencies.

[57] Bayleyegn, National Center for Environmental Health (U.S.), and Division of Environmental Hazards and Health Effects, *Community Assessment for Public Health Emergency Response (CASPER) Toolkit Hausman, Leslie*.

[58] The Weather Channel, "Winter Storm Nemo: Snow, Wind, Coastal Flood Reports," February 13, 2013, http://www.weather.com/news/weather-winter/winter-storm-nemo-reports-20130208.

B. DATA COLLECTION

TweetCharts.com was used to help identify popular hashtags used during the aftermath of the blizzard. On February 8, 2013, the following search terms were used at TweetCharts.com.

- Blizzard + northeast
- Boston + blizzard
- Boston + storm
- New England + blizzard
- Blizzard

Popular hashtags included #blizzard2013, #bosnow, #capecodstorm, #ctstorm, #mastorm, and #nemo. Three were selected for detailed analysis, #bosnow, #capecodstorm, and #mastorm. The three hashtags chosen focused on events in Massachusetts, and could offer perspective on how distinct, yet similar, hashtags might contain varying information.

MDX Online provided a free application called The Archivist, which allows a user to archive tweets for later analysis. Tweets can be saved, and exported for analysis using programs, such as Microsoft Excel, which was used for this study.[59] As of March 5, 2013, The Archivist application used in this study was no longer supported due to changes by Twitter, but a revised version is now available.[60]

C. CODING METHODOLOGY

Tweets were exported to Microsoft Excel, analyzed, and the content coded. Tweets were coded for as many categories as were deemed appropriate; no attempt was made to code only for the "most" applicable category. Rather, all applicable categories were included. Table 1 explains each coding category. The same categories were used for all three hashtags analyzed in this study.

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[59] MIX Online, "The Archivist Desktop by Mix Online," (n.d.), http://visitmix.com/work/archivist-desktop/.

[60] Tweet Archivist, "Tweet Archivist Desktop," (n.d.), http://www.tweetarchivist.com/archivist-desktop/.

Table 1. Content categories for tweet dataset

Time Group	Tweets were coded into groups, based on when a tweet was posted. Tweets were organized into one-hour groups. Tweets were also organized into six- and twelve-hour groups, but those groupings were not useful during analysis. The hourly grouping allows analysis of the evolving nature of conversation on Twitter.
Location Clues	This code indicates whether each tweet contained a written clue to the location of the user or the subject of the tweet. Location clues ranged from specific mentions of a place (e.g.," Copley Square," "outside my window") to less specific information (e.g., "Cambridge," "#somerville"). This study did not attempt to determine if the tweets were geocoded due to limitations of data obtained using The Archivist. Other projects have mapped tweets using more sophisticated techniques, such as a project from the School of Information Studies at Syracuse University,[61] which mapped tweets using the hashtag #BostonMarathon after the bombing of the Boston Marathon on April 15, 2013.
Retweet Status	Tweets were coded with whether they were retweets, or were original tweets. During content analysis, the researchers determined that many "original" tweets were actually identical to each other's, i.e., they were essentially retweets that did not cite the original poster. However, those tweets were coded simply as original tweets.

[61] Starship Nexis, "Tweets from Boston," (n.d.), http://vortex.starshipnexis.com/boston/.

Advice	This category indicates whether the tweet provided advice to residents on dealing with the storm. Advice included ways to avoid carbon monoxide poisoning, how to find or obtain services, and advisements to stay off the roads to allow crews better access, among other items.
Official Info (General and Specific)	These two categories note whether a tweet contains official information, whether general or specific in nature. These codes primarily related how government agencies were responding to the storm and the resulting snow.
Media Info	This group tweets all contained information from various media organizations related to the storm. Many of these tweets contained compilations of pictures and input from individuals, or general media descriptions of the impact of the blizzard. Tweets were included if media organizations were referenced, whether the post originated from an official media account or not. Retweets from individual accounts were also included if they referenced media organizations.
Closures	These were actually four separate categories of tweets that indicate whether a business, government facility/agency, school, or airport was open or closed during the storm. The airport category was initially designed as a catch all for other types of closures, but none was noted besides airport closures.

Weather Info	These two categories indicate that these tweets contained information about weather conditions, either general or specific in nature. General weather updates included comments about how much snow accumulated around town, etc. The specific comments were typically related to weather/snow conditions at a user's residence or other specific location, and particularly, during the beginning of the storm, frequently contained images of the situation being described.
General Info	This category is for users reporting on information about the aftermath of the storm that did not fit into other categories.
Road Information	Tweets containing information about the status of local roads, including highways, arteries, and side streets, were placed into this category.
Transit Information	Tweets in this group had information about public transportation. Most of these related to the MBTA "T," but information about busses, Amtrak, and commuter trains were also included. Transit information was initially included with road information, but mass transit information would have been lost in the volume of road information.
Flooding	Reports of flooding were included in this category.
Power Outages	Tweets discussing power outages or restoration of power were included in this group.
Phone and Utility Status	This group contains tweets about the status of phone and other utilities, such as cable or non-electrical heat.
Shelters	This category of tweets shared information about shelters, including locations.
Personal Experiences	Tweets in this category contained personal experiences, reactions, and observations related to the snowstorm that did not fit into other categories.

Impact	This category was for tweets that described how the storm was impacting the life of the user. Impacts represented by other categories, such as school closures were not included. Also, reports of residents shoveling snow, while copious, were not included.
Requests for help	This category contained tweets that requested assistance in some form. Examples of this category include requests to retweet information, people reporting streets that need plowing, and general requests to help the elderly.
Requests for Information	Tweets in this category were users asking questions related to the storm, which includes questions about open businesses, parking availability, the status of public transit, etc.
Media requests for information	Tweets in this category were from media organizations that requested information from Twitter users. Most often, these were requests for personal pictures of the storm, updates about power, and how users were coping with the aftereffects.
Offers to help	This category contains tweets that were offers to help and reports of people helping others.
Complaints	Tweets in this group were complaints related to the storm, whether related to road plowing, official response, actions of other citizens, etc.
Thanks/Praise	These tweets were expressions of thanks to someone for actions related to the storm, which includes praise for the road clearing efforts, people helping each other, and to media and officials for providing updates.
Empathy	Tweets with this coding contained expressions of sympathy, empathy, or support for residents dealing with the impact of the storm. Most were general in nature.

Tangent	These tweets were tangentially related to the storm. Most were either humorous comments about the weather, or comments relating to a personal agenda.
Off Topic/Unknown	This category included tweets either completely unrelated to the storm, or the content was unknown. Unknown content included foreign language posts, tweets that had no discernible meaning, and tweets that contained a link with no textual indication of the content.
Internet Links	Tweets that contained a link were included. Links were not systematically reviewed as part of this study, although a few were investigated when they appeared to be relevant to the research. The links that were briefly reviewed were primarily images, but website links were also included.
Health Impact	Tweets in this group contained information about how the storm impacted the health of the public, whether general or specific that included tweets about children being poisoned by carbon monoxide, individual reports of people who were cold due to power outages or exposure, and patients prevented by conditions from accessing healthcare.
Health Info	This category of tweets contained health related information, such as information to prevent carbon monoxide poisoning, health risks from snow shoveling, and where to report homeless who may need sheltering. This category was added while coding other categories, when the researcher realized that health related tweets were not simply reports of how the storm affected health, but also included information that could be used to protect health.

Adopt-A-Hydrant	All tweets in this group contained references to the Adopt-A-Hydrant program. Worcester, MA describes the program as a way for citizens to help firefighters quickly locate a fire hydrant. Residents are encouraged to clear the snow around the hydrants near their residence.[62] This category was added during coding of other categories, when it emerged as a theme.

Once the data was coded, it was studied in a variety of ways. Each category was examined according to the time when tweets were posted, to see if content changed over time. Retweet status was evaluated to look for topics that users were more likely to pass on to their followers. Categories were compared to the total volume of tweets, to see which types of conversations were more popular. Tweets were also analyzed to see if certain topics were more likely to contain Internet links. Tweets providing situational awareness were examined to see if they also contained clues about location.

D. ANALYSIS AND CASPER COMPARISON

The data were then compared to the bank of questions recommended for disaster epidemiology in the CASPER Toolkit. The question bank is intended to cover a variety of disaster situations. Therefore, not all questions would be used for a specific CASPER. Questions are organized into 10 general categories.

1. Identification and physical location
2. Demographics
3. Damage and repair
4. General utilities
5. Carbon monoxide exposure
6. Animal safety
7. Supplies and relief
8. Health status

[62] City of Worcester, Massachusetts, "Adopt-A-Hydrant," http://www.worcesterma.gov/dpw/seasonal-information/adopt-a-hydrant.

9. Medical care and prescriptions
10. Communication[63]

E. WORD CLOUD

A word cloud is a visual representation of a given piece of text. Words that appear more frequently are larger, and less frequent words are smaller. The web application Wordle was used to create the word clouds in this study. Wordle.net describes Wordle as a toy, and is not intended as a serious scientific analysis tool for this thesis.[64] However, after coding and analyzing each series of tweets, the decision was made to include them. The researcher felt that they offer a crude visualization of the actual content of each dataset, and could potentially be an indicator of topics popular for discussion. Wordle automatically removes common English words, such as "the," "and," etc. Additionally, the option to convert all letters to lowercase was selected when research revealed that people used various capitalizations in these datasets. To keep a consistent visual format, options, such as font, color, etc., were standardized for the word clouds in this study. After that basic formatting, the word cloud is presented and briefly discussed. Then, the most common words, which appear in the largest font sizes, were removed. Topics that were less frequently discussed for each hashtag become easier to view, and are then briefly discussed.

[63] Bayleyegn, National Center for Environmental Health (U. S.), and Division of Environmental Hazards and Health Effects, *Community Assessment for Public Health Emergency Response (CASPER) Toolkit Hausman, Leslie*.

[64] Wordle, "Wordle—Beautiful Word Clouds," (n.d.), http://www.wordle.net/.

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III. #BOSNOW

The hashtag #bosnow is explored in this chapter. First, the event that prompted the hashtag is described. Then, details about the method specific to this hashtag are explained. Data are then presented and discussed. Finally, the data are compared against the CDC CASPER Toolkit question bank to assess whether it could provide the desired situational awareness.

A. BACKGROUND

On Friday, February 8, 2013, a major winter storm dumped massive amounts of snow across the northeastern United States, which was severe enough that The Weather Channel named the storm Nemo, even though winter storms are not traditionally given names.[65] Boston, Massachusetts was heavily impacted by the storm, with hundreds of thousands of residents left without electrical power. Public transportation in the Boston metropolitan area was shut down for days, and a driving ban was instituted for the entire state. The city received approximately 25 inches of snow, which makes it the fifth-largest snowstorm ever recorded in the city. Logan International Airport was closed, with thousands of flights canceled.[66] The U.S. Postal Service even canceled mail delivery. Several people died because of the storm, including at least two people in Boston who died from exposure to carbon monoxide while sitting in running vehicles to keep warm.[67]

Boston had significant difficulty plowing the roads due to the extreme snowfall. Residents of the Jamaica Plain neighborhood complained of roads not being plowed several days after the storm. Boston Mayor Thomas Menino even issued an apology for the slow pace of snow removal in the city.[68]

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[65] Boston.com, "Historical Snowstorm Yes, Blizzard No—Weather Wisdom," February 11, 2013, http://www.boston.com/news/weather/weather_wisdom/2013/02/historical_snowstorm_yes_blizz.html.

[66] The Huffington Post, "Boston Blizzard: Northeast Snowed in As 'Nemo' Barrels Through," February 10, 2013, http://www.huffingtonpost.com/2013/02/09/boston-blizzard-nemo_n_2650592.html.

[67] Ibid.

[68] Boston Business Journal, "Mayor Menino Apologizes for Streets Still Clogged with Snow After Nemo," February 12, 2013, http://www.bizjournals.com/boston/blog/mass_roundup/2013/02/boston-mayor-menino-apologizes-nemo.html.

B. METHOD

The hashtag #bosnow was selected for in depth analysis, as it was primarily specific to storm-related events in the Boston metropolitan area. While hashtags like #blizzard2013 and #nemo had more overall posts, an initial evaluation suggested that these tags were less likely to contain the specific situational awareness desired by the researcher. Tweets denoted with the hashtag #bosnow were saved using The Archivist application at six different times between February 9 and February 12, 2013, each approximately 12 hours apart (morning and evening), which resulted in six data files, each containing approximately 1,500 tweets. As The Archivist application selects the most recent 1,500 tweets, in some cases, tweets were present in more than one dataset. After removing duplicate tweets, 6,807 tweets were analyzed from the #bosnow hashtag. While not a complete collection of #bosnow tweets from the event, the large volume of information is useful in answering the research questions. Table 2 details when the datasets were acquired.

Table 2. Data acquisition times for #bosnow tweets

Data File	Date Saved	Time Saved (24hr EST)
#bosnow1	2/9/2013	1215
#bosnow2	2/9/2013	2354
#bosnow3	2/10/2013	1342
#bosnow4	2/10/2013	2319
#bosnow5	2/11/2013	1250
#bosnow6	2/12/2013	0015

C. DATA AND GENERAL ANALYSIS

Figure 1 displays the total volume of tweets from this hashtag and the time collected.

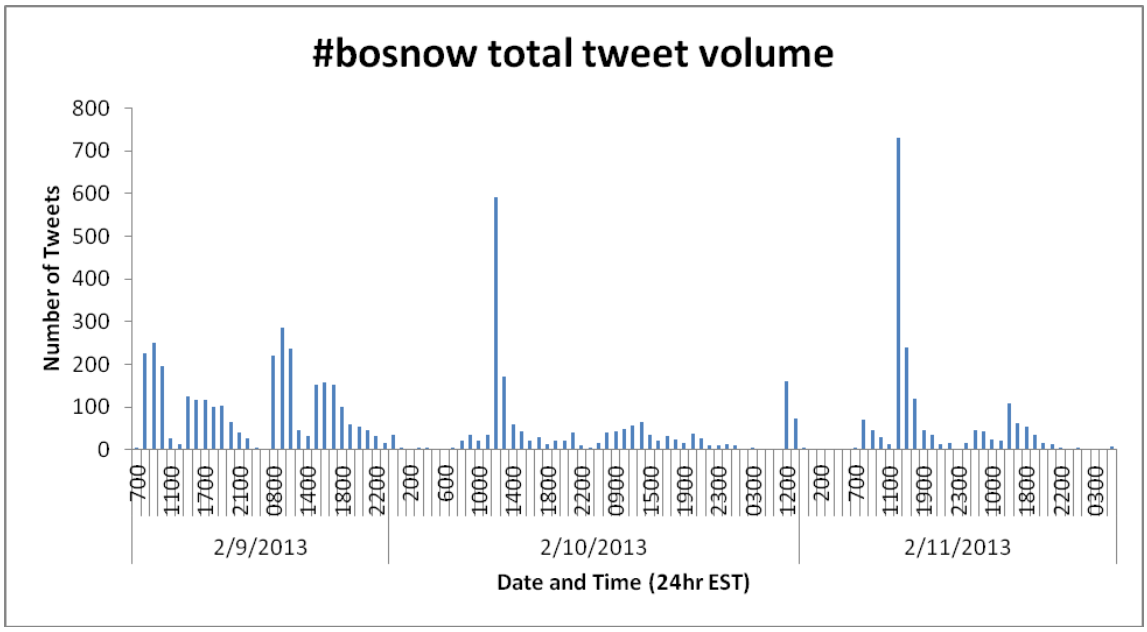

Figure 1. Total volume of tweets using the #bosnow hashtag

Tweets with the hashtag #bosnow contained a wealth of information about the aftereffects of the massive snowfall in the Boston metropolitan area. Figure 2 shows an overview of information contained in the tweets studied.

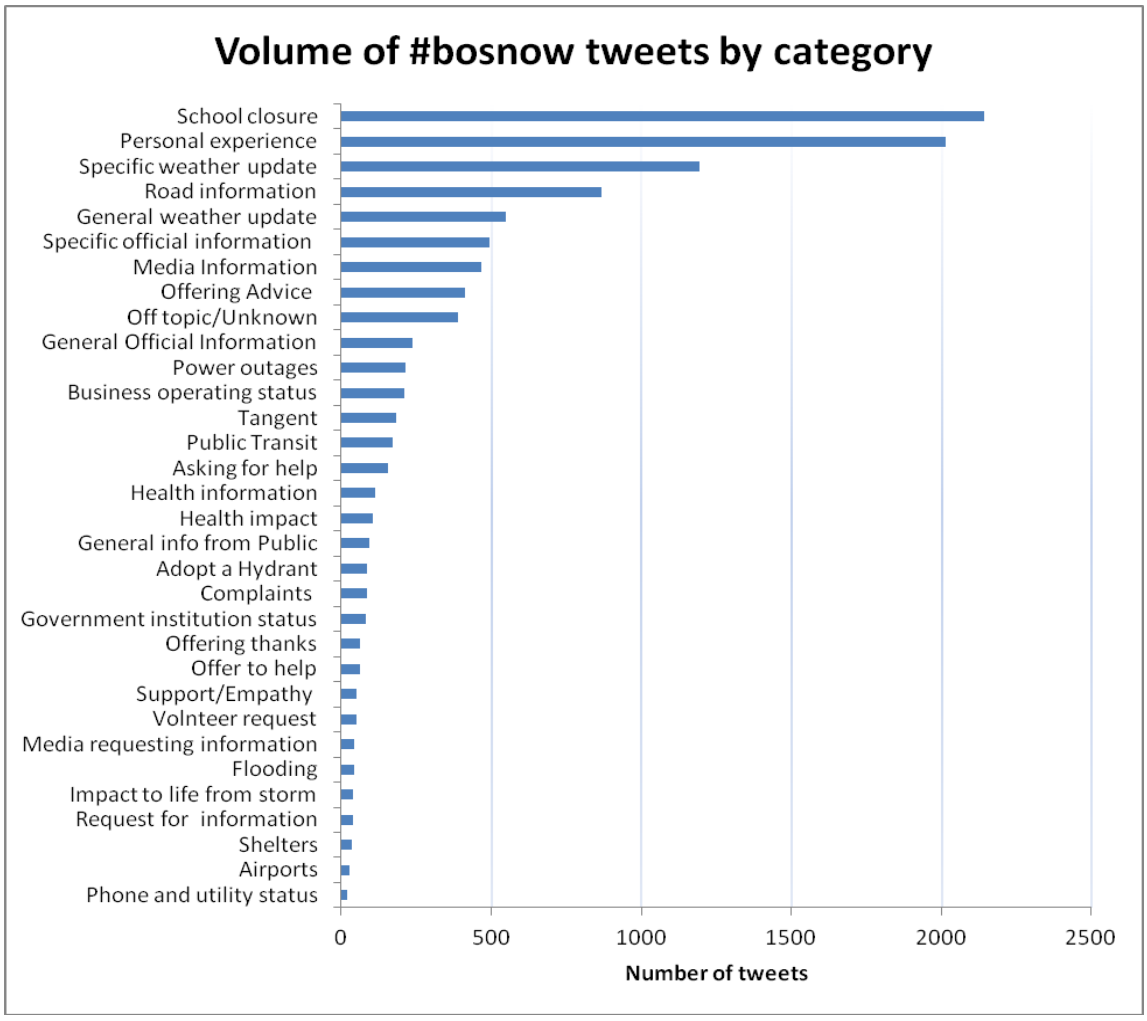

Figure 2. Volume of #bosnow tweets by category

About 40% of the tweets using the #bosnow hashtag were retweets, as illustrated in Figure 3.

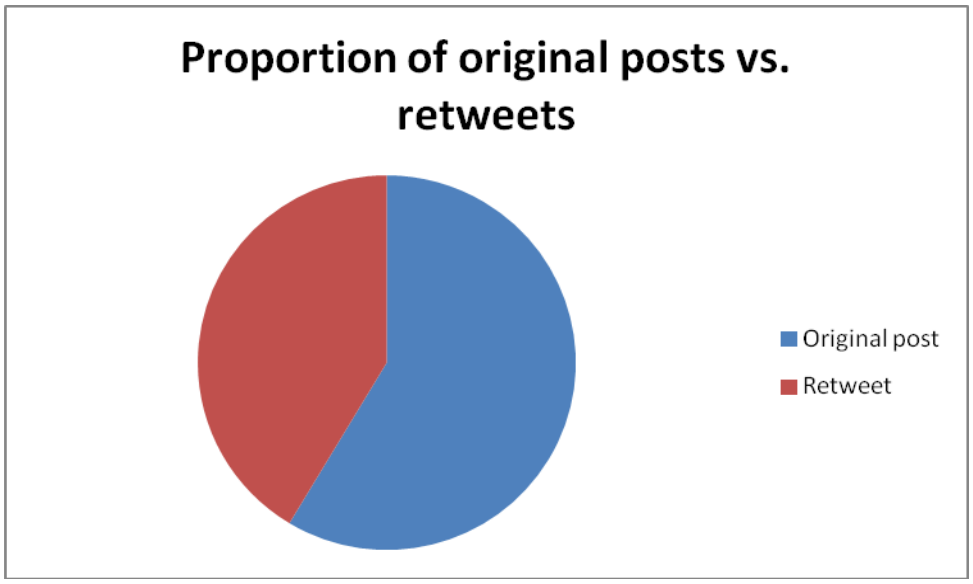

Figure 3. Proportion of #bosnow tweets that were original posts or retweets

The #bosnow hashtag became a useful source of information about school closures in the Boston metropolitan area during the aftermath of the storm. Approximately one-third of all tweets using this hashtag shared something about schools. Looking at this series of tweets from an hourly perspective yields an interesting discovery. Nearly all comments about schools occurred during two separate hours, Sunday, February 10 from nine a.m. to ten a.m., and Monday, February 11, from one p.m. to two p.m. Also, most posts mentioning school closures were retweets. Twitter user @YourTownQuincy tweeted "http://t.co/Kk9kYmd7 #Quincy working to restore power. No word yet on school closing for Monday #bosnow"[69] at 8:37 a.m. on February 10. By 8:58 am, the same user reported, "#Quincy Public Schools closed tomorrow #bosnow."[70]

In addition to sharing school closure information by retweeting, users often expressed both pleasure and displeasure related to the operating status they were reporting. User @vonflakes posted ""@mayortommenino: Boston Public Schools will be

[69] Quincy on Boston.com, Twitter post, February 10, 2013, 11:37 a.m., https://twitter.com/YourTownQuincy.

[70] Quincy on Boston.com, Twitter post, February 10, 2013, 11:58 a.m., https://twitter.com/YourTownQuincy.

closed Tuesday, February 12. #bosnow #bps" thank you Tom.,"[71] while @RudyAlnaal tweeted ""@mayortommenino: Boston Public Schools will be closed Tuesday, February 12. #bosnow #bps" are you kidding? Again?"[72] Both posts occurred at 1:51 p.m. on February 11, 2013.

The operating status of businesses and government institutions were also topics of discussion, with a few mentions of the status of Logan International Airport. Tweets about government status comprised about 1% of all #bosnow tweets, while posts about business status were about 3% of the total. Tweets about Logan International Airport were only 0.3% of the conversation. During the same time that tweets about school closures were dominating (Sunday morning, 2/10), government status tweets appear to be heavily retweeted. However, a closer look revealed that the bulk of those retweets were a message about the status of City Hall that also included closure information about Boston schools, so it is possible that the driver behind the retweet preference was the school status information. Andrew Ryan posted "@Boston_Police just called 24-hour hotline 6 times in a row. No answer. Recorded message. Filed my issue on web #bosnow."[73] User @TedCanova shared "Waiting for an early Valentine's card? Not today! Mail delivery suspended; all New England post offices closed. #BosBliz #Bosnow."[74] An interesting discovery made while analyzing tweets from this category was from a post by Craig Silva, which lead to an analysis of another hashtag, #openinbos, "Want to know what stores/restaurants are open in #Boston? Check out the #openinbos hash tag. #BoSnow #Nemo."[75] The hashtag #openinbos spontaneously emerged in the aftermath of the snowstorm. Users gravitated to this hashtag to discover and share information about businesses able to open despite the massive snow accumulation. Over 75% of the tweets provided information about Boston-area businesses open during the storm, and many of the rest were notices of business closures or inquiries about open businesses. User

[71] Sio, Twitter post, February 11, 2013, 4:51 p.m., https://twitter.com/vonflakes.

[72] يدور, Twitter post, February 11, 2013, 4:51 p.m., https://twitter.com/RudyAlnaal.

[73] Andrew Ryan, Twitter post, February 9, 2013, 7:33 p.m., https://twitter.com/GlobeAndrewRyan.

[74] TedCanova, Twitter post, February 9, 2013, 8:36 a.m., https://twitter.com/TedCanova.

[75] Craig Silva, Twitter post, February 9, 2013, 10:18 a.m., https://twitter.com/craignb.

@andrav23 retweeted “RT @tplepage: Shaws at the Pru is #openinBOS until 5:00 PM. Long lines though and may not find what you need. @universalhub http://t.co ...”[76]

People also used the #bosnow hashtag to share weather information about their specific locations. During the beginning of the event, specific weather updates were a very large part of the conversation among tweets labeled with #bosnow. As the event progressed, the amount of specific weather updates declined significantly. Overall, tweets with specific weather updates comprised 17.5% of all tweets using this hashtag. Weather updates of a more general nature followed a similar trend of declining over time, but were more likely to be retweeted. General updates, even at their peak during the onset of the storm, were much less common than those that were more specific, and comprised approximately 8% of all tweets from #bosnow. Weather updates of both specific and general natures typically contained links. While the links contained in tweets were not systematically analyzed as part of this project, a cursory review indicates that these are primarily links to image files. Mike Petroff inquired, “Where did our bottom two stairs go? #bosnow @WBUR http://t.co/tCKPHANj,”[77] and a similar post from @ holycowcollect “um, where the heck did the street and car go? #brighton #BOSnow #Nemo #blizzard http://t.co/AMD92Zjo http://t.co/waikUAWB via @breakingnews.”[78] General weather updates were obviously less specific, such as a retweet by @ZachVento “RT @BostonGlobe: PHOTOS: Scenes from across the state as residents dug out from the snowstorm. http://t.co/9L80pkj1 #bosnow #blizzard”.[79] When specific and general updates were combined, tweets sharing information about the weather amounted for about 25% of all tweets using the #bosnow hashtag.

[76] Andrea, Twitter post, February 9, 2013, 4:29 p.m., https://twitter.com/andrav23.

[77] Mike Petroff, Twitter post, February 9, 2013, 8:01 a.m., https://twitter.com/mikepetroff.

[78] patricia!, Twitter post, February 9, 2013, 8:17 a.m., https://twitter.com/holycowcollect.

[79] Zachary Vento, Twitter post, February 10, 2013, 4:11 p.m., https://twitter.com/ZachVento.

Figure 4. Picture from this post by user @holycowcollect “um, where the heck did the street and car go? #brighton #BOSnow #Nemo #blizzard http://t.co/AMD92Zjo http://t.co/waikUAWB via @breakingnews.” Picture originally uploaded to Twitter by Heide Penner.[80]

Information about the status of area roads, while not dominant immediately following the storm, was a popular subject of discussion on #bosnow. Road status updates were frequently retweeted, and commonly contained links (presumably images). Comments about roadways were a steady topic of discussion for tweets containing the #bosnow hashtag, which comprised almost 13% of the total. The discussion contained a variety of road-related topics, such as this tweet from Lillian Chan “driving ban still and

[80] Heide Penner, Twitter post, February 9, 2013, https://twitter.com/hmpenner/status/300224568801521664/photo/1.

no MBTA service. I believe it. at least I have power. #BoSnow #snowmageddon #nemo,"[81] A post from Kathryn Alexander noted, "An ambulance is stuck in the snow outside my condo. #nemo #bosnow http://t.co/OCl9nKBB."[82] User Stephanie Ebbert shared, "Roads are clearing but visibility almost nil. Wipers smearing, freezing, lanes randomly cleared. Hard to find & follow the road. #BoSNOW."[83] Also, this retweet from Derek Adesso stated, "RT @EricFisherTWC: Main streets look great. Side roads and neighborhoods? Still not so much. #bosnow #Nemo http://t.co/FEodHHDT."[84]

Figure 5. Picture uploaded by Kathryn Alexander from her post, "An ambulance is stuck in the snow outside my condo. #nemo #bosnow http://t.co/OCl9nKBB." [85]

[81] Lillian Chan, Twitter post, February 9, 2013, 9:36 a.m., https://twitter.com/lillianchan.

[82] Kathryn Alexander, Twitter post, February 9, 2013, 8:11 a.m., https://twitter.com/CaliBlonde8.

[83] Stephanie Ebbert, Twitter post, February 9, 2013, 9:38 a.m., https://twitter.com/StephanieEbbert.

[84] Derek Adesso, Twitter post, February 10, 2013, 2:31 p.m., https://twitter.com/derek_adesso.

[85] Kathryn Alexander, Twitter post, February 9, 2013, 8:11 a.m., https://twitter.com/CaliBlonde8/status/300230469130276864/photo/1.

Figure 6. Picture uploaded to Twitter by Eric Fisher. Retweeted by Derek Adesso "RT @EricFisherTWC: Main streets look great. Side roads and neighborhoods? Still not so much. #bosnow #Nemo http://t.co/FEodHHDT."[86]

[86] Eric Fisher, Twitter post, February 10, 2013, https://twitter.com/ericfisher/status/300687837290971137.

Updates from official sources exhibited a curious phenomenon. Original tweets containing official updates specific in nature were somewhat rare in occurrence, at only about 7% of all #bosnow tweets. However, these types of tweets were very likely to be retweeted by other users. For example, official updates were retweeted more than 10 times for each original tweet from this category. Updates that were more general in nature were not retweeted so heavily, and were less common, and comprising under 4% of #bosnow posts. Messages from official sources were shared throughout the incident.

Examples of specific updates include a retweet by @RoslindalePatch "RT @NotifyBoston: We hear you- we're taking many calls. Crews will be out there working on streets all night. #bosnow,"[87] which was also retweeted by six other Twitter users. This retweet from @krejcismoxie was also retweeted by 21 others, "RT @NotifyBoston: [SERVICE REQUESTS] Request a plow directly from http://t.co/NS8wdyCu front page: http://t.co/HLDH3Zgj #bosnow."[88]

General updates from official sources included "RT @NotifyBoston: Please RT: continue to stay off the road to allow public works/emergency vehicles to operate. #bosnow,"[89] from user @BostonFoodLove, which was also retweeted by 27 others.

Posts offering advice were also heavily retweeted, and shared during all time periods analyzed. Tweets in this category comprised approximately 6% of the total volume of posts from this hashtag. These posts offered citizens actions they could take to protect themselves, request services, and other actions to help them endure the aftereffects of the snowstorm.

Twitter user @NewBostonians shared, "The threat of carbon monoxide poisoning is real. Do not start your car until you have cleared the tailpipe. #bosnow."[90] "RT

[87] Roslindale MA Patch, Twitter post, February 9, 2013, 3:43 p.m., https://twitter.com/RoslindalePatch.

[88] Tiffany, Twitter post, February 9, 2013, 5:23 p.m., https://twitter.com/krejcismoxie.

[89] Boston Food and Love, Twitter post, February 9, 2013, 5:23 p.m., https://twitter.com/BostonFoodLove.

[90] MONewBostonians, Twitter post, February 9, 2013, 8:21 p.m., https://twitter.com/NewBostonians.

@jaykelly26: Called @NotifyBoston for downed powerlines 617-635-4500 For sparking lines call 911 #Bosnow #MAStorm #BosBlizz,"[91] was retweeted by Ayesha Kazmi.

Updates originating from media outlets also were somewhat popular for retweeting, although not at the same rate as information from officials. At the beginning of the storm, media information was being widely shared and retweeted. Media organizations tweeted much less often during the latter part of the blizzard. Zachary Vento retweeted, "RT @BostonGlobe: PHOTOS: Scenes from across the state as residents dug out from the snowstorm. http://t.co/9L80pkj1 #bosnow #blizzard."[92] Ronald Agrella retweeted this media post, "RT @usatoday: Super snowstorm 'Nemo' has been blamed for at least four deaths in New York and Canada. http://t.co/e6sSy9SW #bosnow."[93]

Shortly after the storm, tweets containing information about electrical power status were relatively common. Many of these updates contained clues about location. While many tweets were individual reports of power outages, such as a post from @DDDM9, "No power since midnight. Layers, hat and scarf on while laying in bed! Cats have icicles !! #Blizzard2013 #BOSnow #blizzard,"[94] many posts described the general status of electrical power service. Jessica Bartlett retweeted this information about Duxbury, "RT @DuxFDEM Duxbury is about 90% without power, many roads are impassable and it will be several days until full restoration. #bosnow,"[95] and Art Beecher retweeted, "RT @YourScituate: 100% of people without power in #Scituate according to necn #bosnow."[96] Some tweets contained information about phone service and other utilities, such as cable television, but these were rare. Posts about electrical power status were almost 7% of all #bosnow tweets.

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[91] Ayesha Kazmi, Twitter post, February 9, 2013, 10:10 a.m., https://twitter.com/AyeshaKazmi.

[92] Vento, Twitter post.

[93] Ronald Agrella, Twitter post, February 9, 2013, 9:10 a.m., https://twitter.com/RonAgrella.

[94] DM, Twitter post, February 9, 2013, 9:14 a.m., https://twitter.com/DDDM9.

[95] Jessica Bartlett, Twitter post, February 9, 2013, 10:46 a.m., https://twitter.com/jessmayb3.

[96] Art Beecher, Twitter post, February 10, 2013, 6:07 p.m., https://twitter.com/apbeecher.

Another topic receiving a relatively steady stream of updates was information related to public transportation. While mass transit tweets were not overly frequent, and represented less than 3% of the total, they were a constant topic for tweets over the course of the storm. Zach Tucker retweeted, "RT @BostonAttitude: The MBTA says they will not be able to restore services today #BoSnow,"[97] while Scott Luther put a personal touch on his post, "@mbta down all day. Guess I'm staying in #southie #bosnow."[98] Progress by officials trying to restore service was also a topic of discussion, including @HatchetHagearty, who reported, "#MBTA is reporting that the empty snow-clearing trains are running on time! #congrats #nemo #bosnow,"[99] and this update from Kyle MacDonald, "MBTA now running limited service on C and D lines. #bosnow #nemo #mbta."[100]

People turned to #bosnow to ask for help from each other during the aftermath of the snowstorm, but those tweets were only just over 2% of the conversation. Many requests were general in nature that asked people to check on elderly neighbors and stay off the roads, for example, and were often retweeted. User @The_Divine_Ms_D was one of many to retweet, "RT @NotifyBoston: Please RT: continue to stay off the road to allow public works/emergency vehicles to operate. #bosnow."[101] Later in the event, original tweets asking for assistance began to increase. Boston Mayor Tom Menino had a tweet that was popular for retweeting, including by Alemitu Kassa "RT @mayortommenino: Be good neighbors; take care of one another. Check on elderly residents. Call us with concerns: (617) 635-4500. #bosnow."[102] Twitter user @kianiistarr even shared this important update, "@notifyboston There is some one trying to take their mother to dialysis treatment! We need to plow riverdale road ASAP #bosnow."[103]

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[97] Zach Tucker, Twitter post, February 9, 2013, 8:09 a.m., https://twitter.com/ZachTuckerSM.

[98] Scott Luther, Twitter post, February 9, 2013, 9:53 a.m., https://twitter.com/scott_luther.

[99] Hatchet, Twitter post, February 9, 2013, 9:56 a.m., https://twitter.com/HatchetHagearty.

[100] Kyle MacDonald, Twitter post, February 10, 2013, 3:54 p.m., https://twitter.com/kymacdonald.

[101] Divine Ms D, Twitter post, February 09, 2012, 9:05 a.m., https://twitter.com/The_Divine_Ms_D.

[102] Alemitu Kassa, Twitter post, February 9, 2013, 3:21 p.m., https://twitter.com/treesofgreen2.

[103] princesskiani, Twitter post, February 10, 2013, 12:09 p.m., https://twitter.com/kianiistarr.

In addition to requesting help, Twitter users also offered assistance on #bosnow, but it was less common. Tweets of this nature comprised less than 1% of the total analyzed from this hashtag. User Shane Dunn made this offer, "Happy and able to help anyone in #Southie who needs a little help digging out today. Be safe, folks. #nemo #bosnow."[104]

Residents used #bosnow for both complaints and praise in roughly equal numbers, with slightly more complaints than thanks. Each comprised about 1% of the conversation. While not common compared to the overall number of tweets, Twitter and the #bosnow hashtag made it possible for citizens to communicate directly to officials involved in the response. Examples included praise for a specific official action, such as from @Lynelleluvs, "Thank you for snowplowing my street #bosnow,"[105] and specific items needing attention, like this post from @SynBoga, "Plows driving up and down already cleared roads. Side streets still waiting... #bosnow,"[106] were found in this hashtag.

Tweets were found relating information about how the storm was impacting their health, although they comprised less than 2% of the total. These tweets shared information about people that died from the storm, such as a retweet from @Mephisto808 "RT @WBUR: Trying to stay warm inside car while shoveling out, Boston boy dies: http://t.co/KuQk9qYN #MaSnow #BoSnow."[107] Tweets also mentioned issues like the effects of the cold from shoveling or lack of heating, including this tweet from Kate Birney "No heat. No power. For hours now. It is so cold it hurts. #nationalgridfailure #cityofquincy #nemo #BOSnow #wbur."[108] Mental health pressures from being trapped in their houses were also mentioned, such as user @rachelwrites007, who tweeted, "@amabe421 I'm determined to trek about outside, even if its for a few minutes today. Going stir crazy! #bosnow."[109] Also, some tweets provided reminders that the elderly

[104] Shane Dunn, Twitter post, February 9, 2013, 9:32 a.m., https://twitter.com/shaneadunn.

[105] lynelleluvs, Twitter post, February 10, 2013, 9:32 p.m., https://twitter.com/Lynelleluvs.

[106] SynBoga, Twitter post, February 9, 2013, 5:50 p.m., https://twitter.com/SynBoga.

[107] Mephisto, Twitter post, February 9, 2013, 3:21 p.m., https://twitter.com/Mephisto808.

[108] Kate Birney, Twitter post, February 9, 2013, 8:34 a.m., https://twitter.com/cbirn557.

[109] Rachel, Twitter post, February 9, 2013, 10:17 a.m., https://twitter.com/rachelwrites007.

may need assistance, including Jack Kelly, who posted, “RT @ONEin3: Not everyone in #Boston is a ONEin3er! Know any elderly neighbors who cld use some help shoveling?? #InstantKarma #BoSnow.”[110]

Additionally, information that citizens could use to keep themselves safe and healthy was also available, such as clearing the exhaust before operating vehicles to prevent carbon monoxide poisoning, including Noah Reiter, who tweeted, “2 killed from CO poisoning in Boston post- #nemo Clear exhaust pipes of vehicles and home furnace vents http://t.co/5JDpunkr #bosnow.”[111] The same number of these health information tweets were posted as those about health impact. Both health updates and health information were widely retweeted.

Twitter users also utilized #bosnow to offer empathy and support to those dealing with the aftereffects of the snowstorm. Posts were both personal in nature, such as “good to hear! “@SimmonsCollege: How is everyone doing? We made it through the night safe+sound and now we’re just waiting it out! #bosnow,”“[112] by Whole Foods Symphony, and more general in nature, like a tweet from Laura Elkman, “Thinking of you #boston from #atlanta! #nemo #bosnow with @catherinvaritek http://t.co/h9P1SIEb.”[113] Posts of this nature were less than 1% of the #bosnow tweets analyzed.

In the days following the blizzard, tweets about the Adopt-A-Hydrant program increased. This program encourages residents to volunteer formally to keep a hydrant near their residence free from snow (also clear of vegetation during warmer months), so that firefighters can easily find them.[114] One particular tweet, from @AlertBoston, which was heavily retweeted, contained images from a nearby fire where responders had to clear snow to access the hydrant. The text of the tweet was, “Fire on Mather St. shows

[110] Jack Kelly, Twitter post, February 9, 2013, 10:01 a.m., https://twitter.com/JackKelly111.

[111] Noah Reiter, Twitter post, February 9, 2013, 10:01 a.m., https://twitter.com/noahreiter.

[112] Whole Foods Symphony, Twitter post, February 9, 2013, 9:59 a.m., https://twitter.com /WFM_Symphony.

[113] Laura Elkman, Twitter post, February 9, 2013, 9:19 a.m., https://twitter.com/LauraElkman.

[114] City of Worcester, Massachusetts, “Adopt-A-Hydrant.”

importance of shoveling hydrants. Note: hydrant pictured was not closest to home #bosnow http://t.co/c9FoKSDR."[115] Overall, Adopt-A-Hydrant information was widely retweeted. Some of the original tweets were users posting images of hydrants that they had adopted, which showed that they had cleared snow from around the hydrant, such as this tweet from David Ziegler-Voll, "R2D2 cleared and on standby. #adoptahydrant #bosnow http://t.co/aCb9t7dr."[116] Posts in this category comprised over 1% of the total volume of tweets from #bosnow.

[115] City of Boston OEM, Twitter post, February 10, 2013, 12:38 a.m., https://twitter.com/AlertBoston.

[116] David Ziegler-Voll, Twitter post, February 9, 2013, 3:56 p.m., https://twitter.com/davidtornado.

Figure 7. Pictures posted by @AlertBoston from tweet, “Fire on Mather St. shows importance of shoveling hydrants. Note: hydrant pictured was not closest to home #bosnow http://t.co/c9FoKSDR.”[117]

Although only comprising less than 1% of the tweets analyzed, people did use #bosnow to ask questions on a variety of topics, including Caitlin O’Halloran, who asked, “Is the MBTA going to be open in time for work tomorrow morning? #bosnow

[117] City of Boston OEM, Twitter post, February 10, 2013, 12:38 a.m., https://twitter.com/AlertBoston /status/300478774271672321/photo/1.

#Blizzard2013."[118] User @brainofrich wondered, "@NotifyBoston is overflow emergency parking still available for Boston neighborhoods(JP)? #bosnow,"[119] while @ScituateQDPhoto inquired, "Hearing there may be a warming station at Deer Hill School in Cohasset, can anyone confirm? #bosnow."[120] Finally, @ChristinaJValle "I just want breakfast! Is @DunkinDonuts open? #allston #bosnow #dayafternemo."[121] However, responses to questions posed by users were not apparent. Twitter does allow for private, direct messages between two users, but those are unavailable to uninvolved parties.

The #bosnow hashtag also contained reports of flooding resulting from the storm; however, they were less than 1% of the dataset analyzed. These reports included warnings of possible flooding, including one from Joshua Eaton, "Tomorrow it will be 34 and sunny. Tomorrow night it will be 19. There are 2 feet of snow on the ground. You do the math. #bosnow."[122] Other posts included information about the effects of flooding on the local area, such as, ""Provincetown is technically and temporarily an island" due to break at Ballston Beach in Truro @hgoldstone @wgbhnews #bosbliz #bosnow,"[123] from @TedCanova, a post by Stephanie Ebbert, "RT @GlobeKayLazar: Angry sea took out this house on Salisbury beach #bosnow http://t.co/IUmJGsu8,"[124] and "RT @mikewdonnelly: Pic of Boston's Long Wharf flooding #wcvbsnow #bosnow #Nemo http://t.co/F4sduIiI,"[125] by @10Canesfan.

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[118] Caitlin O'Halloran, Twitter post, February 10, 2013, 6:43 p.m., https://twitter.com/cohalls.

[119] Rich, Twitter post, February 10, 2013, 11:14 a.m., https://twitter.com/brainofrich.

[120] ScituateDailyPhoto, Twitter post, February 9, 2013, 3:47 p.m., https://twitter.com/Scituate QDPhoto.

[121] christina valle, Twitter post, February 9, 2013, 9:45 a.m., https://twitter.com/ChristinaJValle.

[122] Joshua Eaton, Twitter post, February 9, 2013, 6:29 p.m., https://twitter.com/joshua_eaton.

[123] TedCanova, Twitter post, February 11, 2013, 11:07 a.m., https://twitter.com/TedCanova.

[124] Stephanie Ebbert, Twitter post, February 9, 2013, 2:55 p.m., https://twitter.com/StephanieEbbert.

[125] Maureen, Twitter post, February 9, 2013, 11:11 a.m., https://twitter.com/10Canesfan.

Figure 8. Picture retweeted by user @10Canesfan, "RT @mikewdonnelly: Pic of Boston's Long Wharf flooding #wcvbsnow #bosnow #Nemo http://t.co/F4sduIiI," by @10Canesfan.[126]

The #bosnow hashtag also contained a small volume of tweets about shelters for local citizens, which amounted to less than one-half of 1% of the total. Hiawatha Bray tweeted, "#bosnow A few dozen people in Quincy shelter. Recharging their phones like me. More arrivals expected as night comes on,"[127] and @YourTownQuincy shared, "#Quincy is offering to drive people to shelter. Call 617 376 1105 #bosnow."[128]

[126] Mike Donnelly, Twitter post, February 9, 2013, https://twitter.com/mikewdonnelly/status/300275364876394499/photo/1.

[127] Hiawatha Bray, Twitter post, February 9, 2013, 10:40 a.m., https://twitter.com/GlobeTechLab.

[128] Quincy on Boston.com, Twitter post, February 9, 2013, 3:48 p.m., https://twitter.com/YourTownQuincy.

Many tweets contained Internet links, but did not have any textual clues as to the content of the post. These links were not explored, but over 51% of #bosnow-tagged tweets contained a link.

As Twitter is open for use to anyone willing to complete the brief enrollment process, it is not surprising to find that some tweets did not relate to the loose structure of the hashtag #bosnow. What was unexpected was that the overall volume of tweets that were completely unrelated to the hashtag comprised a very small portion of the overall tweet volume. Analysis found that most of the off-topic tweets occurred towards the beginning of the time period studied. Further analysis of this category shows that the majority of the off-topic tweets are retweets of this particular post, such as from MariAn Gail Brown, "RT @chowandchatter: Road sign humor RT @smebulok: RT @bmgallagherjr: Only in New England. #bosnow #nemo http://t.co/ZKzgiXNZ."[129] Since approximately 2/3 of all off-topic posts were retweets of this specific post, the link was investigated, which revealed an image of a road sign stating, "The roads are wicked slippery." Along a similar vein, a small but steady collection of tweets used the storm as a springboard to talk about something tangentially related. Examples are tweets that used the storm as an excuse to discuss global warming. Another popular tangent involved making a play on the name of the storm (named Nemo by some news outlets) to the Disney movie "Finding Nemo."

[129] MariAn Gail Brown, Twitter post, February 9, 2013, 8:53 a.m., https://twitter.com/MariAn GailBrown.

Figure 9. Humorous picture uploaded to Twitter by Brian Gallagher, Jr., which was retweeted by many users[130]

Tweets were also coded if they contained mentions about personal experiences during the storm. An example is a tweet mentioning what the user is having for dinner, or a mention of a movie the user is watching during the storm. While many useful posts, such as weather updates, contained personal comments of this nature, personal comments

[130] Brian Gallagher, Jr., Twitter post, February 9, 2013, https://twitter.com/bmgallagherjr/status/300012271046914048/photo/1.

that did not contain situational awareness were combined with tangent and off-topic posts to create a usefulness category. Surprisingly, the vast majority of #bosnow tweets conveyed at least some information about the storm.

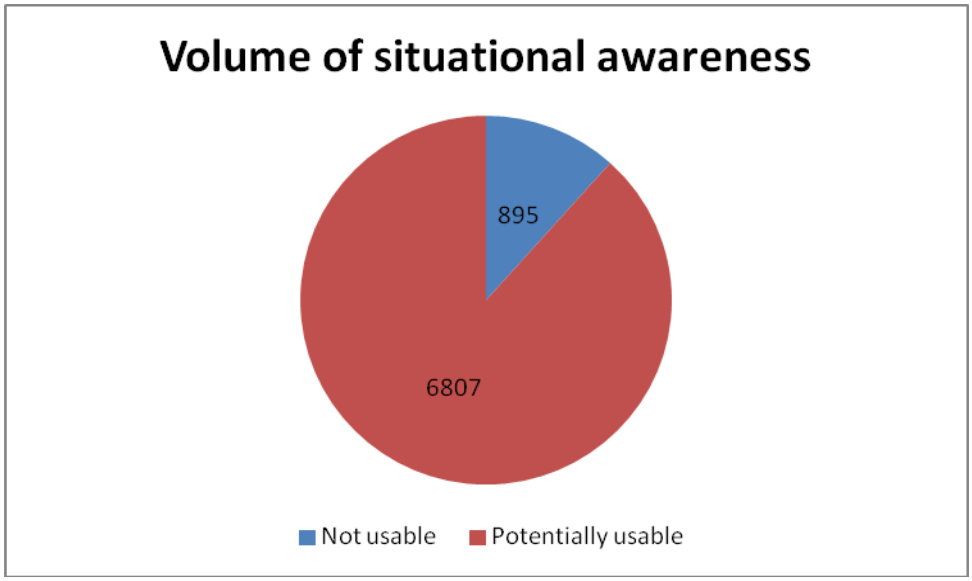

Figure 10. Amount of tweets containing some level of situational awareness

D. CASPER-SPECIFIC ANALYSIS

Data obtained with the #bosnow hashtag contained many elements identified in the CASPER toolkit. This information can help agencies improve their response after a disaster.

1. Identification and Physical Location

The suggested questions in this category allows the researcher to note the location of the person interviewed. While Twitter users do not typically include their address in their Twitter profiles, location clues were readily available from the tweets studied. The #bosnow hashtag effectively filtered discussion so that tweets with that hashtag primarily related to events in Boston during and after the snowstorm. Jess Infante shared, “Door knob height snow at the back door. Not going anywhere anytime soon. #blizzard

#bosnow #Charlestown pic.twitter.com/za21zI2R."[131] Her post demonstrates the type of location information typically found on the hashtag. It is reasonable to assume that the post references the Charlestown neighborhood of Boston.

Also, while not part of this study, Twitter gives users the option to include their latitude and longitude with their posts. Additionally, many smartphone cameras automatically add geographical information to photos.[132]

2. Demographics

For the most part, much of the information in this section that the CDC recommends was not found in tweets with the #bosnow hashtag. However, many posts could be assumed to be referring to the users' primary residence, as evidenced when reviewing tweets about weather updates. For example, it is a reasonable assumption that Twitter user @pandanichols spent the night at their primary residence based on their tweet, "Anyone else's street look like mine? @universalhub we're snowed in completely on Chesterton. #BoSnow #blizzard http://t.co/1046f8Mu."[133]

While people did not use Twitter to report that they did not feel a need to evacuate, shelters were mentioned. Hiawatha Bray reported "#bosnow A few dozen people in Quincy shelter. Recharging their phones like me. More arrivals expected as night comes on."[134] Other tweets about shelters included a query from @ScituateQDPhoto, "Hearing there may be a warming station at Deer Hill School in Cohasset, can anyone confirm? #bosnow,"[135] and "#Quincy is offering to drive people to shelter. Call 617 376 1105 #bosnow,"[136] from @YourTownQuincy. Tweets about shelters comprised only a minute fraction of the total tweets analyzed from #bosnow.

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[131] Jess Infante, Twitter post, February 9, 2013, 8:06 a.m., https://twitter.com/JessicaInfante.

[132] Rob Hidgon, "Geotagging Your Photos–The Phototripper Podcast," *The Phototripper Podcast*, September 8, 2012, http://phototripper.net/geotagging-your-photos/.

[133] Crash Safely, Twitter post, February 9, 2013, 8:36 a.m., https://twitter.com/pandanichols.

[134] Hiawatha Bray, Twitter post, February 9, 2013, 10:40 a.m., https://twitter.com/GlobeTechLab.

[135] ScituateDailyPhoto, Twitter post, February 9, 2013, 3:47 p.m., https://twitter.com/Scituate QDPhoto.

[136] Quincy on Boston.com, Twitter post, February 9, 2013, 10:40 a.m., https://twitter.com/Your TownQuincy.

However, the news media did not report widespread evacuations from this weather event, so the low volume of tweets about shelters is unsurprising.

3. Damage and Repair

Twitter provided a great deal of information in this category. Although no tweets were found describing damage to a residence from the storm, #bosnow was widely used to share details about the impact of the storm on individuals. Many posts even included pictures of snowfall, such as a tweet from Curt Nickisch, reporting, "Tree-damaged car in Jamaica Plain: @WBUR #bosnow pic.twitter.com/Iejgn4wB."[137] Tweets sharing information about the extent of the weather were very common, which comprised about 25% of all tweets studied from this hashtag, with those relating specific information about the extent of the weather comprising the bulk of the volume. This post from user @ddayhere is fairly representative of the type of specific weather updates found, "#bosnow Out the window this morning. The wheels are covered with snow. http://t.co/Gr12vuXe."[138]

Some information about flooding in the area was also tweeted, including "Salisbury orders mandatory evacuation of beach residents; giant surf damaged two homes in 200 block of No. End Blvd. #BoSnow,"[139] and "Big waves, but no major flooding in Revere. "We were fortunate," Revere Fire Chief Gene Doherty. #BoSnow,""[140] both from Kathy McCabe. As the primary issue with this storm was snowfall, it is not unexpected for tweets about flooding to compromise less than 1% of overall tweets.

Twitter users also shared information about their cleanup efforts, which for this storm, primarily consisted of snow removal. Twitter user @mcledin mentioned, "The digging out has begun #bosnow #boston #blizzard http://t.co/0uLQP0S3."[141] Daniella

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[137] Curt Nickisch, Twitter post, February 9, 2013, 10:40 a.m., https://twitter.com/GlobeKMcCabe.

[138] D Day, Twitter post, February 9, 2013, 10:40 a.m., https://twitter.com/ddayhere.

[139] Kathy McCabe, Twitter post, February 9, 2013, 9:30 a.m., https://twitter.com/GlobeKMcCabe.

[140] Kathy McCabe, Twitter post, February 9, 2013, 10:32 a.m., https://twitter.com/GlobeKMcCabe.

[141] Matt, Twitter post, February 9, 2013, 8:32 a.m., https://twitter.com/mcledin.

Santos shared a post typical of those about shoveling, “Back at it again! Morning shoveling. #blizzard2013 #bosnow #Snomageddon @cbsboston @JimCantore http://t.co/A25hS4EP.”[142] While people really did not use the #bosnow hashtag to report that they lacked the resources or ability to clean up, reports asking people to help each other were discussed, such as this from @ONEin3, “Take a break from playing in the snow and check on your elderly neighbors who may need some help shoveling! #InstantKarma #BoSnow.”[143]

4. General Utilities

The #bosnow hashtag was an excellent source for information about utilities. Electrical status was a popular topic for discussion, which comprised almost 7% of all tweets studied from #bosnow. Many of these tweets relayed the electrical status of individual residents, such as this post from @persoconchii, “*counts her lucky stars* ok.. so Quincy in general has no power, but we in N. Quincy (Quincy Shore Dr) got ours back! hoorah!! #bosnow,”[144] Other posts detailed the extent of overall outages, including a tweet from Ted Canova, “Boston power outages- Hyde Park hardest hit: 2,800 out of Boston’s 10,000 without power. h/t @phillipWGBH #Bosbliz #Bosnow.”[145] Telephone, garbage, and natural gas were also discussed, but were much less common. The CDC recommends asking about what type of heating source a person is using after a disaster.[146] While #bosnow did not offer answers to that question, many users reported on

the lack of heat in their residences, including Kate Birney, “No heat. No power. For hours now. It is so cold it hurts. #nationalgridfailure #cityofquincy #nemo #BOSnow #wbur.”[147]

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[142] Daniella Santos, Twitter post, February 9, 2013, 9:42 a.m., https://twitter.com/Daniella_jp.

[143] ONEin3 Boston, Twitter post, February 10, 2013, 2:51 p.m., https://twitter.com/ONEin3.

[144] Anna, Twitter post, February 9, 2013, 3:08 p.m., https://twitter.com/persoconchii.

[145] Ted Canova, Twitter post, February 9, 2013, 8:11 a.m., https://twitter.com/TedCanova.

[146] Bayleyegn, National Center for Environmental Health (U. S.), and Division of Environmental Hazards and Health Effects, *Community Assessment for Public Health Emergency Response (CASPER) Toolkit Hausman, Leslie*, 63.

[147] Birney, Twitter post.

5. Carbon Monoxide Exposure

While Twitter was not an ideal way to learn how many local residents were potentially exposed to carbon monoxide, quite a few posts warned other users about the risks of carbon monoxide, and reported the deaths of residents killed from exposure. Tweets about carbon monoxide were frequently shared with others by retweeting, including "Definitely watch out for deadly carbon-monoxide poisoning if you are stuck or clearing car. Clear exhaust pipe. #bosnow,"[148] from The Boston Globe. As demonstrated above, Twitter did provide decent information about power outages, which public health agencies could use as an indicator of carbon monoxide exposure. When the power goes out, people may be more likely to use generators and grills, which can release deadly carbon monoxide.

6. Animal Safety

Questions in this category relate to threats to safety from animals after a disaster. Mosquitoes, snakes, and alligators were the only animals specifically mentioned, and obviously, those would be unlikely to pose a significant threat after a major snowstorm. Questions in this section did not relate to pets or livestock, although #bosnow tweets did discuss pets.

7. Supplies and Relief

A lot of information in this category in tweets used the hashtag #bosnow. The first group of CDC suggested questions relate to drinking water. No tweets were noticed in #bosnow that discussed drinking water availability. Some users complained of dwindling food supplies, and others reported businesses that were open, sometimes expressing gratitude at having found something besides the provisions they had remaining. Timothy Scholl shared, "Anybody know if there are any stores open in Jamaica plain, preferably Hyde sq or Jackson? Need laundry detergent & dinner supplies. #bosnow."[149] Tweets using the #openinbos hashtag were mostly related to sharing information about

[148] The Boston Globe, Twitter post, February 9, 2013, 9:56 a.m., https://twitter.com/BostonGlobe.

[149] Timothy Scholl, Twitter post, February 9, 2013, 4:42 p.m., https://twitter.com/stopaction.

businesses open to the public after the storm. User @sugarplum1125 provided a typical example, "#openinbos whats open in boston for food need something in back bay for my hotel guests #backbay #hotel140 #boston #nemo."[150]

The lack of available transportation in the area was also a big topic for discussion. Governor Patrick's driving ban was a popular subject, including a comment by Sean Leahy, "No driving ban needed here. Nature (with help from plow) imposes its own 30" barrier. #bosnow #snow… http://t.co/8GB94kHa,"[151] and "When will MA driving ban be lifted? @MassGovernor Patrick spokesperson: Governor "will reassess midday." #BosBliz #Bosnow,"[152] from Ted Canova. Public transportation was also mentioned on #bosnow. Many tweets simply relayed the status of mass transit in the area, but some described the direct impact of not having transportation, such as Amanda Kendrick's post, "Can't get to church because the T is closed, so we're watching live from the fort. #winning #bosnow http://t.co/GnmoLywo."[153] A similar tweet came from Twitter user @MyOmegaCentauri, "No barbershop for me because the #MBTA is still pretty much shutdown. AY Cabin Fever has set in. I love snow but it's Snowmageddon #BoSnow."[154]

The final suggested question in this section asks a person what their greatest need is at the moment. Twitter is a useful platform to obtain information of this sort. While it is not possible to determine if a tweet is the most important need of the user, the fact that this person bothered to post something implies some amount of importance. Such an open-ended question can allow researchers to identify issues previously unrecognized. For instance, many Twitter users reported roads that had been neglected by plows to Boston Mayor Menino's Office of Constituent Engagement Twitter account @NotifyBoston. JJ Foley's Café reported, "@NotifyBoston Oakview terrace Jamaica plain 02130. #boSnow no plow in almost 24 hrs. http://t.co/aCyUH2qa,"[155] while Jim

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[150] Samjo, Twitter post, February 9, 2013, 5:17 p.m., https://twitter.com/sugarplum1125.

[151] Sean Leahy, Twitter post, February 9, 2013, 8:27 a.m., https://twitter.com/leahysean.

[152] Ted Canova, Twitter post, February 9, 2013, 8:58 a.m., https://twitter.com/TedCanova.

[153] Amanda Kendrick, Twitter post, February 10, 2013, 11:55 a.m., https://twitter.com/amandarivet.

[154] TWITTING U, Twitter post, February 10, 2013, 12:43 p.m., https://twitter.com/MyOmegaCentauri.

[155] JJ Foleys Cafe, Twitter post, February 9, 2013, 3:57 p.m., https://twitter.com/JJFoleysCafe.

Mitchell mentioned, "@NotifyBoston #bosnow Mt. Vernon St in Dorchester(near Boston St) hasn't been plowed. Thank you for all your hard work."[156]

8. Health Status

Information was available about health status using the #bosnow hashtag. People reported minor injuries from snow shoveling, anxiety and stress from being stuck in their residences. Deaths from carbon monoxide poisoning were reported, as mentioned in the carbon monoxide section.

9. Medical Care and Prescriptions

One person shared how the snow was preventing someone from receiving care for a chronic condition. The #bosnow hashtag did not appear to offer any information about whether people had enough prescriptions to last until the snow could be cleared.

10. Communication

These questions assess what source an individual primarily uses to obtain information, and whether this person reports receiving any warnings. As previously mentioned, Twitter was a good source of information about threats faced by citizens, such as that from carbon monoxide, fire hydrants buried in snow, and other hazards. Another useful feature of Twitter for this section of a CASPER is retweeting. Many messages on #bosnow were frequently retweeted by other users. Understanding what types of posts are likely to be retweeted can help responders increase the reach of their messages.

E. WORD CLOUD

It is readily visible from Figure 11 that posts providing information about schools were a large part of the overall tweets on #bosnow, which matches the findings of the researcher. Figure 12 shows the same word cloud after the most frequent words have been removed. Other words, such as plows, ban (refers to the statewide driving ban), streets, shoveling, monoxide (carbon monoxide), among others start to become visible.

[156] Jim Mitchell, Twitter post, February 9, 2013, 5:23 p.m., https://twitter.com/shoota306.

These terms also match common themes discovered by this research. While words are presented with no accompanying context, crude concepts rise to the top.

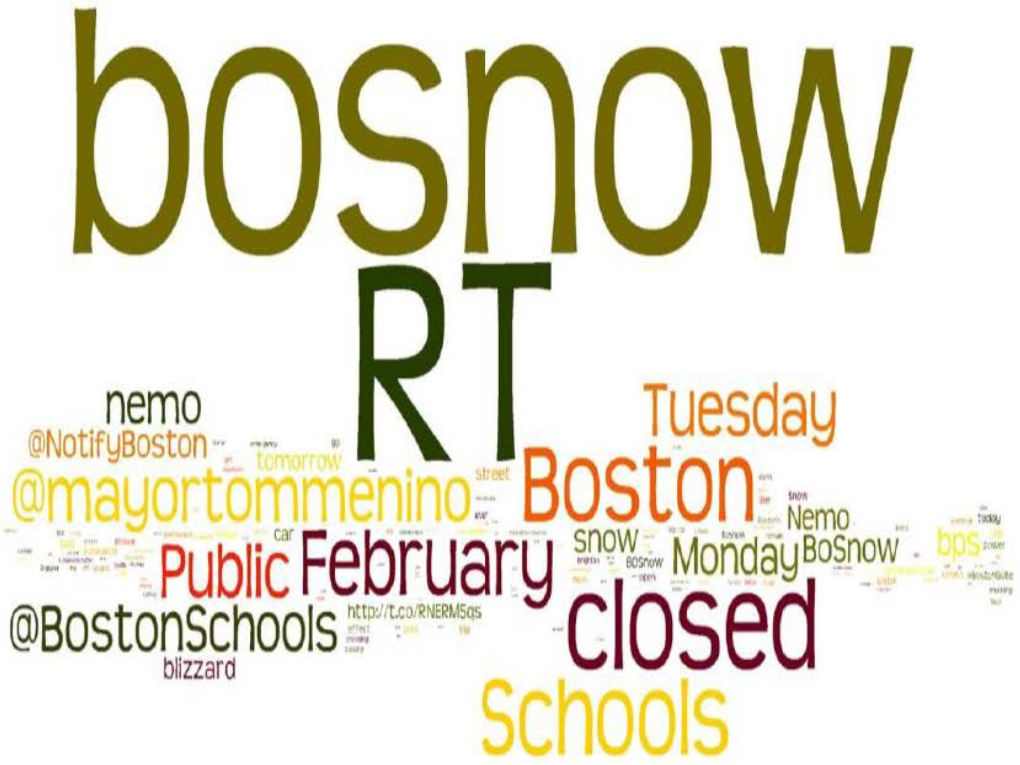

Figure 11. Word cloud created from #bosnow dataset[157]

[157] Created at Wordle, "Wordle—Beautiful Word Clouds."

Figure 12. Word cloud created from #bosnow dataset edited to remove the most frequent words[158]

[158] Created at Wordle, "Wordle—Beautiful Word Clouds."

IV. #MASTORM

In this chapter, the hashtag #mastorm is explored. Background is provided on the specifics of the weather event under study. Method details specific to this dataset are presented. Similar to the previous chapter, the data are then presented and analyzed with a comparison to the CASPER toolkit.

A. BACKGROUND

The major snowstorm that affected Boston on February 8, 2013, also affected large portions of the rest of the state of Massachusetts, among other states in the northeast region. In preparation for the storm, Massachusetts Governor Deval Patrick enacted a statewide driving ban, Amtrak trains were sidelined, and the state's largest airport, Logan Airport, was closed.[159] Nstar and National Grid reported more than 375,000 customers without power in Massachusetts, primarily in the southeastern part of the state.[160] Even the Pioneer Valley, in western Massachusetts, reported heavy snowfall.[161]

B. METHOD

The hashtag #mastorm was selected for in depth analysis. It was selected because the name indicated that it might contain information about storm-related events specific to the state of Massachusetts. Tweets using the hashtag #mastorm were saved using The Archivist application at six different times between February 9 and February 12, 2013, each approximately 12 hours apart (morning and evening), as shown in Table 3, which resulted in six data files, each containing approximately 1,500 tweets. As The Archivist application selects the most recent 1,500 tweets, in some cases, tweets were present in more than one dataset. After removing duplicate tweets, 4,065 tweets were analyzed from

[159] Masslive.com, "Massive Snowstorm Nemo Drops 2 Feet of Snow on Northeast," February 9, 2013, http://www.masslive.com/news/index.ssf/2013/02/massive_snowstorm_nemo_drops_2.html.

[160] Masslive.com, "Winter Storm Nemo Knocks out Power to 375,000-plus in Massachusetts," February 9, 2013, http://www.masslive.com/news/index.ssf/2013/02/winter_storm_nemo_knocks_out_p.html.

[161] Masslive.com, "Winter Storm Nemo Buries Western Massachusetts in Snow, but Fails to Reach 'Blizzard' Level in Pioneer Valley," February 9, 2013, http://www.masslive.com/news/index.ssf/2013/02/region_recovers_from_non-blizz.html.

the #bosnow hashtag. While not a complete collection of #mastorm tweets from the event, the large volume of information is useful in answering the research questions.

Table 3. Time and date when #mastorm tweets were acquired

Data File	Date Saved	Time Saved (24hr EST)
#mastorm1	2/9/2013	1216
#mastorm 2	2/9/2013	2357
#mastorm3	2/10/2013	1343
#mastorm4	2/10/2013	2317
#mastorm5	2/11/2013	1251
#mastorm6	2/12/2013	0015

C. DATA AND GENERAL ANALYSIS

Tweets with the hashtag #mastorm contained plenty of information about the impact of the storm on the state of Massachusetts. Figure 13 shows the overall volume of tweets analyzed for this chapter, and are organized by the hour the tweet was posted. Figure 14 shows an overview of the content contained in the tweets studied.

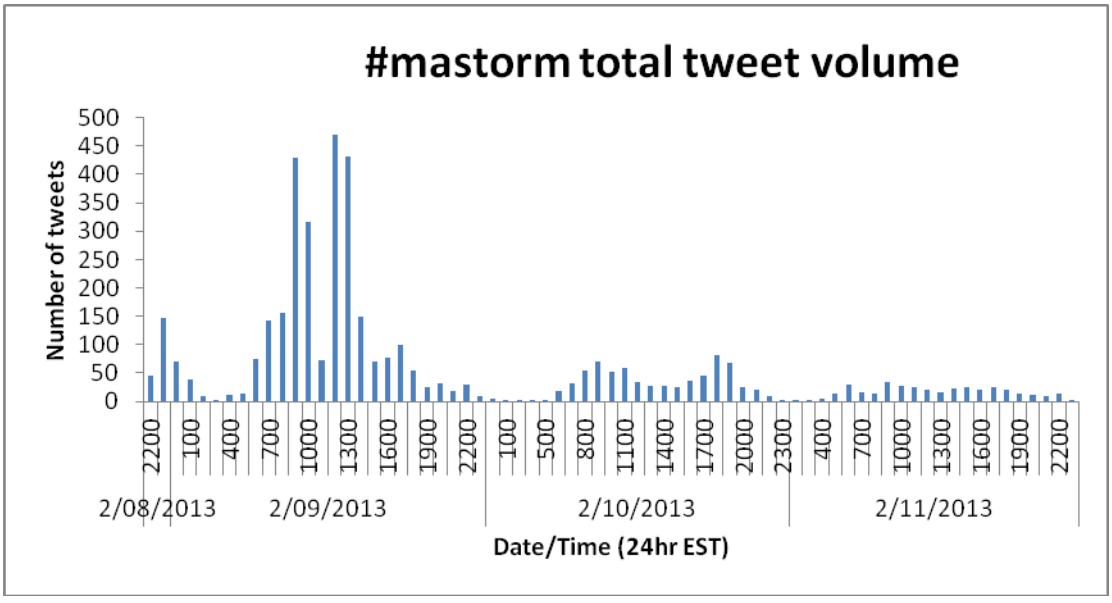

Figure 13. Total volume of #mastorm tweets over time

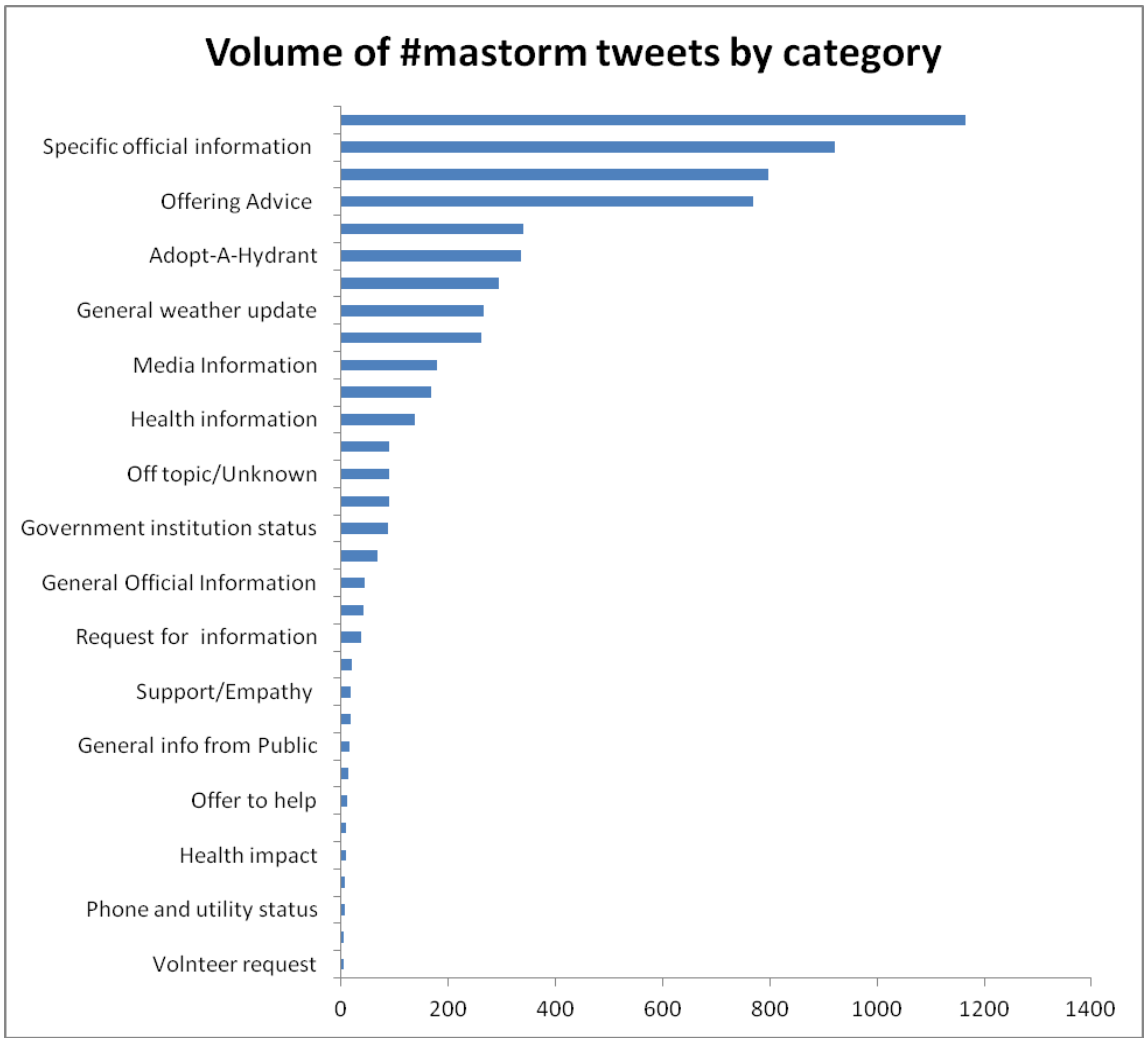

Figure 14. Total volume of #mastorm tweets by category

Overall, about 75% of tweets using the #mastorm hashtag were retweets, as illustrated by Figure 15.

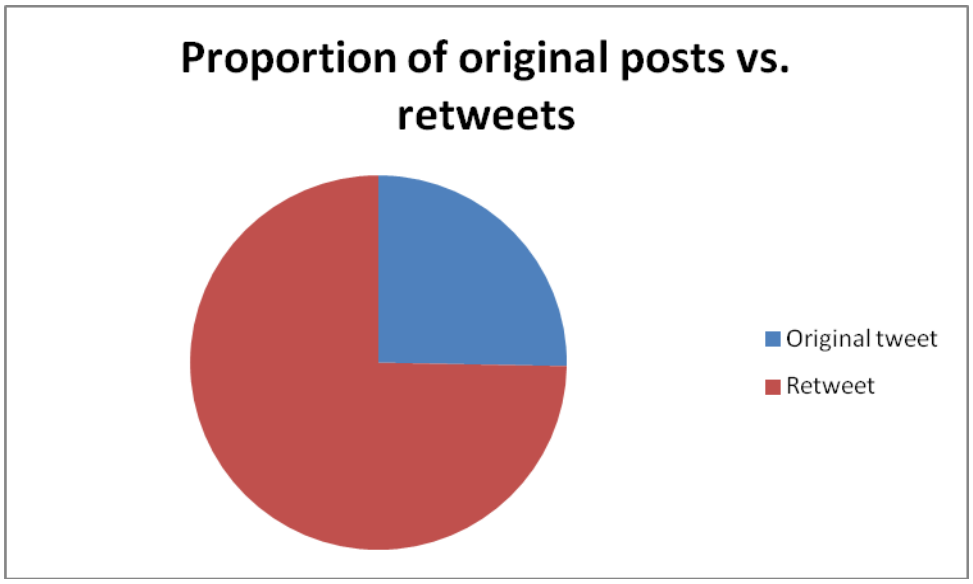

Figure 15. Proportion of original tweets and retweets

While the #bosnow hashtag contained a significant number of tweets related to school closures, #mastorm contained very little mention of school closure information, and comprised less than 1% of all #mastorm tweets studied. One tweet that was retweeted by five others was "Fall River just canceled school for Monday, indicating concern about length of cleanup. #MAstorm #snowRI (h/t @Will_Richmond)."[162]

Once again, the operating status of businesses, government, and airports were discussed on #mastorm. These tweets were also likely to be retweeted. Information about airports was a bit more frequent than on the #bosnow hashtag, but still less than 1% of the total volume of tweets analyzed. While no hashtags similar to #openinbos were found, people did inquire about and report on the operating status of businesses. The Sentinel & Enquirer, a newspaper in Fitchburg, MA, referred users to their Facebook page by posting, "Do you know of a supermarket, coffee shop or gas station that's open? Share here: http://t.co/IKyL2MLq #MAStorm."[163] Tweets about businesses and government each accounted for over 2% of all #mastorm posts in this analysis.

[162] Ted Nesi, Twitter post, February 9, 2013, 5:37 p.m., https://twitter.com/tednesi.

[163] Sentinel Enterprise, Twitter post, February 9, 2013, 1:10 p.m., https://twitter.com/SentandEnt.

Massachusetts Governor, Deval Patrick's tweets, under the user name @MassGovernor, were popular for retweeting, including a submission by @JMengz001, "RT @MassGovernor: Asking all non-emergency state employees to stay home tomorrow. #MAStorm."[164]

Much like with the #bosnow hashtag, users shared specific and general weather updates using the #mastorm hashtag; however, those updates were not as frequent. Also similar to #bosnow, tweets using #mastorm usually contained links. Weather updates of both types occurred throughout the storm. John Casey shared this post, "Aftermath in #Somerville #Nemo #MAStorm http://t.co/HL2sMrfZ."[165] Another update shared a few times was the tweet from Gina Tomaine, "Dude, where's my car? #MAstorm #nemo #boston #blizzard #brighton @universalhub http://t.co/sRHCJfvA."[166] Specific weather updates were slightly more common than general ones, with each comprising approximately 7% of the total volume of tweets for this hashtag.

[164] Tackle Berry, Twitter post, February 8, 2013, 11:33 p.m., https://twitter.com/JMengz001.

[165] John Casey, Twitter post, February 9, 2013, 10:24 a.m., https://twitter.com/jfcasey.

[166] Gina Tomaine, Twitter post, February 9, 2013, 10:47 a.m., https://twitter.com/gtomaine.

Figure 16. Picture from Gina Tomaine's tweet, "Dude, where's my car? #MAstorm #nemo #boston #blizzard #brighton @universalhub http://t.co/sRHCJfvA"[167]

[167] Tomaine, Twitter post.

Figure 17. Picture uploaded in this tweet by John Casey, “Aftermath in #Somerville #Nemo #MAStorm http://t.co/HL2sMrfZ.”[168]

[168] Casey, Twitter post.

People using the #mastorm hashtag shared a significant amount of information about the status of roads following the storm. On February 9, from about 12 p.m. until 2 p.m., tweets talking about roads dominated the conversation tagged with #mastorm. While that tapered off, roads were a relatively constant theme during the time period analyzed, which accounted for over 28% of all #mastorm tweets studied. Other users also very heavily shared roadway information via retweeting. However, very few of these tweets about streets and highways contained links or images. Over one-third of all tweets (N=392 of 1165) in this category were retweets from @MassDOT, the official account of the Massachusetts Department of Transportation, such as "RT @MassDOT: #MAStorm: I-90E/W now open to propane and tandems from the New York Border to Springfield - Speed Limit remains at 40 MPH."[169] Another third of the posts (N=444 of 1165) in this category were retweets from MA Governor Deval Patrick, including, "RT @MassGovernor Driving ban lifted immediately 4 Nantucket County & for all communities west of I-91 #MAStorm #ynnsnow."[170]

Updates from official sources followed a similar pattern as the #bosnow hashtag. While original tweets with specific official information were much more common than on #bosnow, these types of tweets were very heavily retweeted by other users. Specific official updates were shared throughout the storm, and comprised more than 22% of all #mastorm tweets in this study. Specific updates of this nature were primarily relating to the status of roadways. More general in nature Updates were far less frequent, and consisted of only approximately 1% of the conversation, but were also often retweeted, such as "RT @MassGovernor: For all snow storm related tweets from MA state gov't, follow #MAStorm."[171]

[169] hi_jules, Twitter post, February 9, 2013, 4:17 p.m., https://twitter.com/hi_jules.

[170] YNN Albany, Twitter post, February 9, 2013, 1:08 p.m., https://twitter.com/YNNAlbany.

[171] Robin SwaffordJensen, Twitter post, February 9, 2013, 9:13 a.m., https://twitter.com/rjensen08.

One popular tweet for retweeting ended up being truncated, “RT @MassDOT: #MAStorm: Statewide Travel Ban remains in effect all Massachusetts Roads. Crews total 3600+ overnight plowing roads. Avoid ...”[172] The retweeting process added a few characters to the new tweet, and the actual advice was no longer clear.

Official advice was a very popular theme on #mastorm, and comprised almost 19% of the total volume of tweets from this hashtag, and was often retweeted. Advice was provided on a variety of subjects, including this retweet by @DISASTER911UT “RT @MassEMA: Reminder: Call 211 for shelter and other information if needed. Save 911 lines for emergencies. #MAStorm.”[173] Also, Renato Rodriguez retweeted, “RT @MassEMA: If you still have power, keep your cell phones fully charged in the event of a power outage #Mastorm.”[174]

Media outlet updates were less common on #mastorm than #bosnow, but they were also frequently retweeted. These media posts were just over 4% of the total conversation studied. User @Wadmissions retweeted, “RT @BostonGlobe: SNOWFALL TOTALS: See how much your area received: http://t.co/fIPFffiT #bosnow #mastorm #blizzard #nemo.”[175] Media tweets offered general information about the storm, including a retweet from @Shelshand, “RT @BostonGlobe: VIDEO: Powerful waves crash against homes, streets flood from nor’easter. http://t.co/t1Nw3JLa #bosnow #mastorm #blizz ...”[176]

Tweets containing information about electrical power service were very common on #mastorm, during the entire time period studied, and were commonly retweeted. Unlike #bosnow, however, most did not contain clues about location, but were broader updates, including @TwoOsinGoose who retweeted, “RT @MassEMA: 12AM (2/9) outages in MA (rounded): NGRID 168K, NSTAR177K, Total 345K generally southeast

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[172] Eliza Berneche, Twitter post, February 9, 2013, 8:22 a.m., https://twitter.com/Elizaberneche.

[173] Rockwell, Twitter post, February 8, 2013, 10:33 p.m., https://twitter.com/DISASTER911UT.

[174] Renato Rodriguez, Twitter post, February 8, 2013, 11:14 p.m., https://twitter.com/Comodon_Johnson.

[175] Wheelock Admissions, Twitter post, February 9, 2013, 9:18 a.m., https://twitter.com/Wadmissions.

[176] Shelshand, Twitter post, February 9, 2013, 2:15 p.m., https://twitter.com/Shelshand.

portion of state #Mastorm."[177] Also, individuals provided reports, such as @shirleytyc, who posted, "In Quincy ma and power off for two hrs already n counting. #mastorm #blizzard2013 gonna be a long nite. God bless n stay safe n warm!"[178] Posts about electrical power status comprised almost 20% of all tweets studied using the #mastorm hashtag.

Similar to #bosnow, sporadic reports of the operating status of other utilities, such as phone and cable television, were also posted, but they were very rare.

Mass transit related tweets were more common on #mastorm than on #bosnow, and were retweeted at a higher frequency. This category of tweets comprised over 6% of all #mastorm posts analyzed. The Massachusetts Department of Transportation (@MassDOT) tweeted, "#MAStorm: #MBTA Service remains suspended, all routes, today, Saturday, Feb. 9. http://t.co/PvUNmLQP,"[179] which was retweeted by 49 other users.

People only made a few requests for help using the #mastorm hashtag, which makes this category far less than 1% of the total conversation. Karen Winsper posted, "@NSTAR_News Hoping that my dead end street in Rochester is not last on your list! No power=no heat and no water too. #MAstorm @MassGovernor."[180]

A few tweets also reported on people who had volunteered to help others in some way. Adam Coombs posted, "My family shoveled out my elderly neighbor. He looked so happy. There were tears in his eyes. #Mastorm."[181]

Using Twitter to say thanks to someone was more common than for complaints, but many of the thankful tweets were retweets towards the end of the storm. The bulk of the retweets offering praise were two very similar tweets, one from the Massachusetts Emergency Management Agency that shared, "Special thanks on 2/11 to @Mass_211

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[177] Garrett, Twitter post, February 9, 2013, 12:12 a.m., https://twitter.com/TwoOsinGoose/.

[178] Shirley, Twitter post, February 8, 2013, 11:02 a.m., https://twitter.com/shirleytyc.

[179] Mass. Transportation, Twitter post, February 9, 2013, 8:00 a.m., https://twitter.com/MassDOT.

[180] Karen Winsper, Twitter post, February 11, 2013, 6:43 a.m., https://twitter.com/kwinsper.

[181] Adam Coombs, Twitter post, February 9, 2013, 10:52 a.m., https://twitter.com/AdamCWriting.

workers helping w/ #MAStorm response & all year in sharing free resources for local services. #211Day,"[182] and the other from Governor Patrick, "Special thanks to @Mass_211 workers helping w/ #MAStorm response & all year in sharing free resources for local services. #211Day."[183] Similar to tweets on roadways from @MassDOT, these tweets became truncated when retweeted by other users, e.g., "RT @MassEMA: Special thanks on 2/11 to @Mass_211 workers helping w/ #MAStorm response & all year in sharing free resources for local ...".[184] Posts offering thanks to someone consisted of roughly 2% of #mastorm tweets.

Complaints were varied, but mostly focused on the driving ban imposed by Governor Patrick, such as "@massgovernor #Mastorm There is a part of the state called "Western Massacusetts," May we please drive now your highness?"[185] These critiques were about 1% of the conversation on #mastorm.

Health impacts from the storm were not shared frequently on #mastorm, and comprised well under 1% of all tweets with this hashtag. Just a few reports appeared, including one from Patrick Delahanty, "Although the #MAstorm is over, remember to check in on the elderly or disabled. I'm going to go rescue @nigoki now...".[186] However, information about how to prevent a health impact from the storm was fairly frequent, at over 3% of the conversation. This actionable information was also highly retweeted, including this post from @lirael_abhorsen, "RT @SomervilleCity: When shoveling, be sure to clear snow from appliance vents outside to prevent carbon monoxide poisoning #MAstorm #Ne ...,"[187] and another from Jeff McQueen, "RT @MassEMA: Another #shoveling tip - shovel out the car exhaust pipe before starting car #Mastorm."[188]

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[182] MEMA, Twitter post, February 11, 2013, 3:50 p.m., https://twitter.com/MassEMA.

[183] Deval Patrick, Twitter post, February 11, 2013, 4:30 p.m., https://twitter.com/MassGovernor.

[184] New England WX/News, Twitter post, February 11, 2013, 4:04 p.m., https://twitter.com/NEnglandWx.

[185] Neil Darragh, Twitter post, February 9, 2013, 12:35 p.m., https://twitter.com/NeilDBuffa.

[186] Patrick Delahanty, Twitter post, February 9, 2013, 5:34 p.m., https://twitter.com/PDelahanty.

[187] JHL, Twitter post, February 9, 2013, 9:10 a.m., https://twitter.com/lirael_abhorsen.

[188] Jeff McQueen, Twitter post, February 9, 2013, 10:29 a.m., https://twitter.com/SWMOturfguy.

Twitter users also demonstrated some empathy when using the #mastorm hashtag. Similar to #bosnow, posts were both specific, such as Edwin Diaz who tweeted, "Omg!! stay safe up there RT @gtomaine: Dude, where's my car? #MAstorm #nemo #boston #blizzard #brighton @universalhub http://t.co/t6T4rxNF,"[189] and more general in nature, including one from Judy Converse, "Thinking of family & friends back east in the grip of #MAStorm! Stay warm and safe everyone!"[190] Tweets in this category comprise less than 1% of the total volume studied.

Adopt-A-Hydrant information was shared on #mastorm, and comprised about 8% of the conversation; however, most of those tweets were posted at the beginning of the time period studied. During the first few hours of the storm, many retweets reminded citizens about the program. Some tweets specifically mentioned the program, while others simply reminded people to clear hydrants in their area. "RT @MassEMA: When shoveling, please help dig out nearby hydrants! It could save lives during a fire #MAstorm"[191] was retweeted over 300 times.

People also used the #mastorm hashtag to ask questions of other users. Many were specific, including a question from Jackie Troche, "Anyone know where to get wood or gas in Plymouth? #MAStorm,"[192] and another from JJBoston, "Any hotels with heat and power in Plymouth MA area?? Looking to book 3 rooms for a few days ASAP #mastorm."[193] These inquiries comprised less than 1% of the conversation, and, similar to #bosnow, did not appear to be answered.

Reports of flooding were also noticed on #mastorm. The Boston Globe posted this tweet, "VIDEO: Powerful waves crash against homes, streets flood from nor'easter. http://t.co/t1Nw3JLa #bosnow #mastorm #blizzard #nemo."[194] The link in the tweet is no

[189] Edwin Diaz, Twitter post, February 9, 2013, 10:52 a.m., https://twitter.com/eddy_1984.

[190] Judy Converse MPH RD, Twitter post, February 9, 2013, 12:00 p.m., https://twitter.com/Nutr CareAutism.

[191] NEMLECFoundation, Twitter post, February 9, 2013, 9:08 a.m., https://twitter.com/NEMLECInc.

[192] Jackie Troche, Twitter post, February 9, 2013, 7:06 p.m., https://twitter.com/HeyNonni.

[193] JJ, Twitter post, February 11, 2013, 7:03 a.m., https://twitter.com/JJBoston.

[194] The Boston Globe, Twitter post, February 9, 2013, 1:55 p.m., https://twitter.com/BostonGlobe.

longer active, so the video could not be reviewed. These posts were uncommon, and comprised less than one-third of 1% of the conversation.

Quite a few tweets mentioned shelters opened because of the storm, which comprised over 4% of all #mastorm tweets studied. Many were truncated again when the message was retweeted by other users, including Christine Thompson, "RT @MassEMA: RT @massgov: If you've lost power and/or heat due to #MAStorm, you can get local shelter & warming center information b ..."[195] Other users like @Aline_Carr recognized this, and modified the tweet to read, "MT @massgov Lost power or heat due to #MAstorm? Call 211 for local shelter & warming center info. #nemo #blizzard #hmrd."[196] The "MT" typically stands for "Modified Tweet," and indicates that someone has altered the original text.[197]

The hashtag #mastorm, like #bosnow, had numerous tweets that contained a link, but did not have any contextual clues about what the link referenced. These links comprise about 1% of all tweets, but were not investigated. Over 28% of all #mastorm posts contained a link.

Similar to the #bosnow hashtag, tweets using #mastorm primarily related to the winter storm, but unrelated tweets were posted throughout the event.

Adding personal experiences that did not also contain situational updates, as was done for the #bosnow chapter, shows that #mastorm posts were even more likely to have some level of situational awareness than #bosnow (see Figure 18).

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[195] Christine Thompson, Twitter post, February 9, 2013, 5:26 p.m., https://twitter.com/redcrossmom.

[196] Aline, Twitter post, February 9, 2013, 5:29 p.m., https://twitter.com/Aline_Carr.

[197] Business Insider, "Twitter," August 2, 2010, http://www.businessinsider.com/twitter-abbreviations-2010–8.

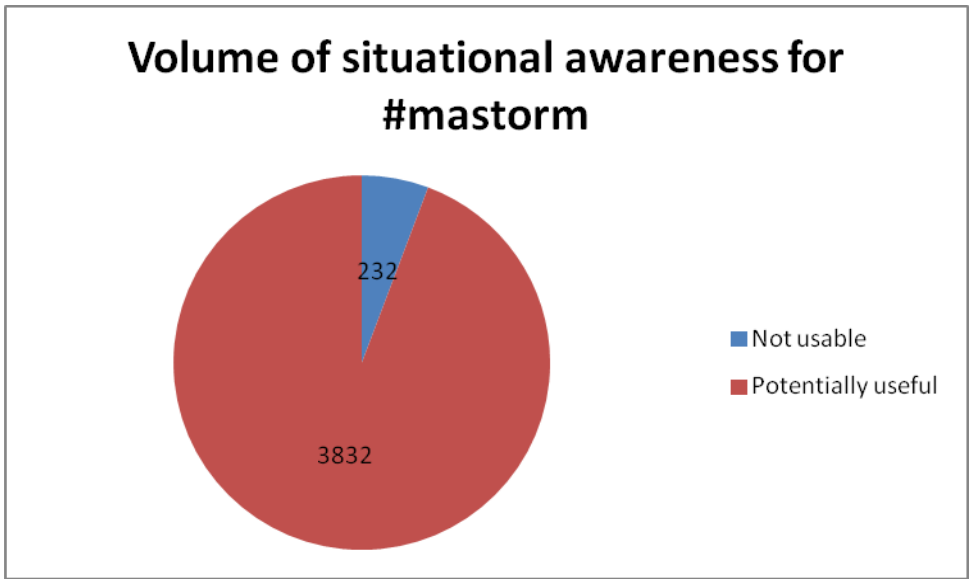

Figure 18. Amount of tweets containing some level of situational awareness

D. CASPER-SPECIFIC ANALYSIS

As with the analysis of #bosnow tweets, those using the #mastorm hashtag were compared with the CDC CASPER question bank.

1. Identification and Physical Location

The suggested questions in this category allow the researcher to note the location of the person interviewed. Similar to #bosnow, many tweets using #mastorm had clues to the location being discussed. Using a hashtag was a common method, such as a post by @CohassetBOH, "Power is out all throughout #Cohasset. Follow @CohassetBOH to receive continuous updates of the response. #MAstorm @CohassetMariner."[198] The post seems to refer to power outages in the town of Cohasset. Other posts simply mentioned the name of the location in question, including @starsfadeaway, who tweeted, "Westfield 22 inches, Springfield 15 inches. It's still snowing #Mastorm."[199]

[198] Cohasset BOH, Twitter post, February 8, 2013, 10:37 p.m., https://twitter.com/CohassetBOH.

[199] Sara, Twitter post, February 9, 2013, 7:07 a.m., https://twitter.com/starsfadeaway.

2. Demographics

Much like with #bosnow, demographic information was somewhat limited, but much could be inferred from the context of a tweet. Someone posting, “Seeing snow drifts of at least 3’ on deck and in driveway. Went out twice last night with the snowblower too. #MAStorm #blizzard2013 #revere” probably spent the previous night at at the house. Information about whether someone owned or rented a home was not noticed in tweets from this hashtag.

The hashtag #mastorm was not really used to report that a user needed to evacuate or use a shelter, but information about shelters was shared and widely retweeted. The town of Cohasset, MA shared the following tweets, “Some things not to bring to the #Cohasset Charging Station: car batteries and the like @MassRegion4b @CohassetMariner #Mastorm,”[200] and “Thank you to the #NationalGuard for transporting 5 #Cohasset residents to the @RedCross regional shelter in Weymouth @MassRegion4b #Mastorm.”[201]

3. Damage and Repair

Once again, Twitter was an excellent source to learn about damage from the storm, as #mastorm contained a wealth of posts reporting on local conditions. One post, which was retweeted by several users, describes roof damage, “RT @MassEMA: Why roof clearing is important: MT @SNEWeather partial roof collapse at house in Marlborough Mass http://t.co/8hJb7YlD #MAstorm.”[202] The link goes to a picture that was shared on Twitter, but not using #mastorm or any other hashtag (see Figure 19). The #mastorm hashtag also contained many updates describing personal updates on the impact of the storm, often containing images. Twitter user @meobrienii offers an example of a typical personal update, “The view from our apt from door #boston #mastorm #blizzard #southend http://t.co/abVWG1wY.”[203]

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[200] Cohasset BOH, Twitter post, February 10, 2013, 7:14 a.m., https://twitter.com/CohassetBOH.

[201] Cohasset BOH, Twitter post, February 10, 2013, 7:19 a.m., https://twitter.com/CohassetBOH.

[202] Russell, Twitter post, February 10, 2013, 5:55 p.m., https://twitter.com/olebballfan.

[203] MEOBII, Twitter post, February 10, 2013, 7:12 p.m., https://twitter.com/meobrienii.

Figure 19. Picture uploaded to Twitter by @SNEWeather, found in the popular retweet, "RT @MassEMA: Why roof clearing is important: MT @SNEWeather partial roof collapse at house in Marlborough Mass http://t.co/8hJb7YlD #MAstorm." [204,205]

While flooding was not a significant issue following the storm, local reports of flooding were found on #mastorm, as well as more generalized discussion regarding flooding. Massachusetts State Senator Bob Hedlund posted, "Much of Distr still coping Atlantic Av Hull hit hard Breakwater wiped out. Scit Shelter very busy. Staff there working very hard. #MaStorm."[206] User @MassDCR posted, "Be glad ur NOT driving:

[204] Russell, Twitter post.

[205] SNE Weather Coverage, Twitter post, February 10, 2013, https://twitter.com/SNEWeather.

[206] Bob Hedlund, Twitter post, February 10, 2013, 6:28 p.m., https://twitter.com/SenBobHedlund.

Winthrop Prkwy @ Short Beach closed due 2 flooding frm splash over. Driving ban remains in effect! #MAStorm."[207]

While it was less common than on #bosnow, Twitter users also used the #mastorm hashtag to report on cleanup activities. Similar to #bosnow, clean up primarily consisted of shoveling snow. Nelly Do provided a typical example: "#Time for an #upper #body #workout with #shoveling #snow :) #mastorm #blizzard http://t.co/3Nashviy."[208]

4. General Utilities

The #mastorm hashtag was popular for sharing information about electrical power outages following the storm. Unlike #bosnow, however, tweets were less likely to have location clues. While some were personal, such as a post from Brett Rossi, "10:30am update: No power. Radio says it won't be restored until Sunday night. We think we only got a foot. #MAstorm,"[209] most were general in nature, like @MassEMA "10AM (2/9) outages in MA (rounded): NGRID 164K, NSTAR 249K, Total 413K #MAstorm."[210] Very few references to utilities other than electrical service were posted, but a few did mention phone and cable services.

5. Carbon Monoxide Exposure

Similar to #bosnow, #mastorm was not used to self-report exposure to carbon monoxide. However, Alex Bloom reported, "Five taken to #Brockton Hospital for carbon monoxide poisoning. Family was heating apartment using gas stove http://t.co/NwCbmzFe #MAStorm."[211] Additionally, a moderate amount of information was posted on ways people could protect themselves from carbon monoxide exposure, including a plea from @OccupyNemo, "If you lose heat, do not heat home with gas stove/oven! The carbon monoxide can kill! #Nemo #MAstorm (1)."[212]

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[207] MassDCR, Twitter post, February 9, 2013, 9:32 a.m., https://twitter.com/MassDCR.

[208] Nelly Do, Twitter post, February 9, 2013, 12:03 p.m., https://twitter.com/nellydough.

[209] Brett Rossi, Twitter post, February 9, 2013, 10:30 a.m., https://twitter.com/BreettR4763.

[210] MEMA, Twitter post, February 9, 2013, 10:43 a.m., https://twitter.com/MassEMA.

[211] Alex Bloom, Twitter post, February 11, 2013, 5:12 p.m., https://twitter.com/AlexB_ENT.

[212] Occupy Nemo, Twitter post, February 9, 2013, 10:39 a.m., https://twitter.com/OccupyNemo.

6. Animal Safety

Once again, this category is seeking to understand what threat, if any, is posted to local residents from wildlife, including mosquitoes and snakes. Information on this subject was neither found nor expected on #mastorm. Although not part of the CASPER questions for this section, people did mention pets on #mastorm, much like with #bosnow.

7. Supplies And Relief

The hashtag #mastorm contained a lot of information about supplies and relief. A lack of potable water did not seem to be a significant problem following the storm, and was not discussed much in the tweets analyzed. However, Karen Winsper did mention "@NSTAR_News Hoping that my dead end street in Rochester is not last on your list! No power=no heat and no water too. #MAstorm @MassGovernor."[213] A few reports also contained instances of dwindling food supplies, including one from Phillippe Patry, "We have lots of beers but no food. The storm is bad ! #MAstorm #bostonblizzard."[214] Timothy P. Murray provided a typical post about available disaster relief, "If you're still in need of local services like housing, food, or clothing in the aftermath #MAStorm, Dial 2-1-1 for free resources #211Day."[215] While a hashtag detailing open establishments similar to #openinbos was not discovered, information was available about the status of businesses where people could replenish supplies. The Sentinel & Enterprise created a clearinghouse of sorts by directing users to their Facebook page: "Do you know of a supermarket, coffee shop or gas station that's open? Share here: http://t.co/IKyL2MLq #MAStorm."[216]

Much like the #bosnow hashtag, #mastorm was used frequently to comment on the lack of transportation because of the storm. Many people used #mastorm to express their feelings on the statewide ban on driving in Massachusetts, such as

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[213] Winsper, Twitter post.

[214] Phillippe Patry, Twitter post, February 8, 2013, 10:48 p.m., https://twitter.com/PhilippeParty.

[215] Timothy P. Murray, Twitter post, February 11, 2013, 3:29 p.m., https://twitter.com/MassLtGov.

[216] Sentinel Enterprise, Twitter post.

@Call_Me_Clumsy, who tweeted, ""@MassGovernor: We will let you know when the travel ban is lifted. But for now, the ban is still in effect. #MAStorm" Soon pleaseeeeeeeee."[217] Twitter users also shared information on the status of the driving ban, including the Sentinel & Enterprise, "BREAKING NEWS: Gov. Patrick lifts driving ban for Nantucket, west of I-91 immediately; rest of state at 4 p.m. #MAStorm."[218] Public transportation, mostly the MBTA in Boston, was also discussed. An example retweeted several times was a post from the Massachusetts Department of Transportation: "#MAStorm: #MBTA service remains suspended today, Sunday. Goal: restoring service on Monday, Feb 11. Latest: http://t.co/39539nTV."[219]

Once again, many clues about the greatest needs of residents were available from tweets with the #mastorm hashtag. Lucy Costa inquired "Any recommendations for selecting a good generator and generator safety tips? Asking on behalf of church members. #mastorm #preparedness."[220] User @effigies asked on behalf of a friend, "Friend, with <1yo son, without power near 500 Hancock St. in Quincy. Anybody know if there's anywhere with power in the area? #MAstorm."[221]

8. Health Status

Much less information was available on #mastorm regarding the health status of Twitter users than on #bosnow. As mentioned in the previous section, some reports were posted about carbon monoxide exposure, but no reports appeared concerning minor injuries, unlike #bosnow. Information that could be used to protect health was common, and widely retweeted, including @massgov "@MassEMA If you have lost power, don't use the gas stove or oven for heat. #MAStorm."[222]

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[217] Amy, Twitter post, February 9, 2013, 12:38 p.m., https://twitter.com/Call_Me_Clumsy.

[218] Sentinel Enterprise, Twitter post.

[219] Mass. Transportation, Twitter post, February 10, 2013, 6:47 a.m., https://twitter.com/MassDOT.

[220] Lucy G. Costa, Twitter post, February 10, 2013, 10:30 a.m., https://twitter.com/lgctweets.

[221] effigies, Twitter post, February 9, 2013, 12:59 p.m., https://twitter.com/effigies.

[222] Mass.gov, Twitter post, February 9, 2013, 9:36 a.m., https://twitter.com/massgov.

9. Medical Care and Prescriptions

Medical care and prescription information was not discussed on #mastorm.

10. Communication

The CASPER questions try to determine where people are getting their information, and whether they have heard any disaster response information. The hashtag #mastorm was widely used to share information. As mentioned in previous sections, information on carbon monoxide was frequently discussed and often retweeted, including specific actions that people could take.

E. WORD CLOUD

Similar to the #bosnow hashtag, the word cloud in Figure 20 provides a quick way to review some of the most popular words contained in #mastorm. It is apparent that Twitter users frequently mentioned the travel ban; therefore, it was removed for Figure 21. Other themes identified in the research, including hydrants (fire hydrants), outages, shoveling, start to become clear in Figure 21, after the most frequent words have been removed.

Figure 20. Word cloud for #mastorm tweets[223]

Figure 21. Word cloud for #mastorm tweets edited to remove the most frequent words[224]

[223] Created using Wordle, "Wordle—Beautiful Word Clouds."

[224] Ibid.

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V. #CAPECODSTORM

This chapter analyzes the hashtag #capecodstorm, and is organized similar to the previous two chapters. Background and method details specific to the hashtag are discussed. Data is first presented, then analyzed, and compared against the CASPER framework. Finally, a word cloud is included.

A. BACKGROUND

The winter storm investigated during the previous chapters also had a significant impact on the Cape Cod area of southeastern Massachusetts. A significant portion of the cape was left without power following the storm.[225]

B. METHOD DETAILS

The hashtag #capecodstorm, while not very active overall in terms of tweet volume compared to #bosnow or #mastorm, still contained a significant amount of useful information about the storm. The hashtag was selected to evaluate whether a hashtag that was named for an area with a smaller population might have differing information from the hashtags for larger areas.

Tweets using the hashtag #capecodstorm were saved using The Archivist application at six different times between February 9 and February 12, 2013, each approximately 12 hours apart, as shown in Table 4. After removing duplicate posts, 123 tweets were analyzed from the #capecodstorm hashtag.

[225] Cape Cod Today, "Cape Cod Bruised and Battered by Winter Storm," February 9, 2013, http://www.capecodtoday.com/article/2013/02/09/17048-cape-cod-bruised-and-battered-winter-storm.

Table 4. Date and time when #capecodstorm tweets were obtained

Data File	Date Saved	Time Saved (24hr EST)
#capecodstorm1	2/9/2013	1215
#capecodstorm2	2/9/2013	2353
#capecodstorm3	2/10/2013	1341
#capecodstorm4	2/10/2013	2318
#capecodstorm5	2/11/2013	1250
#capecodstorm6	2/12/2013	0015

C. DATA AND GENERAL ANALYSIS

Figure 22 shows the overall volume of tweets analyzed during this study, organized by the hour the tweet was posted. Figure 23 shows an overview of information contained in the tweets studied. About one-third of tweets with the #capecodstorm hashtag were retweets, as shown in Figure 24.

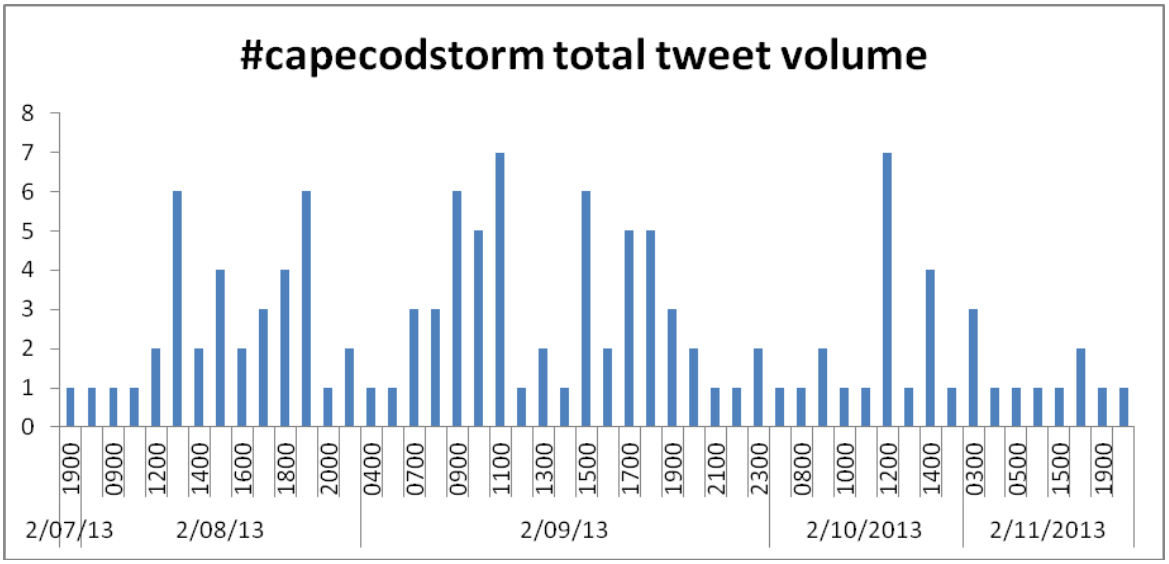

Figure 22. Total volume of tweets using the #capecodstorm hashtag

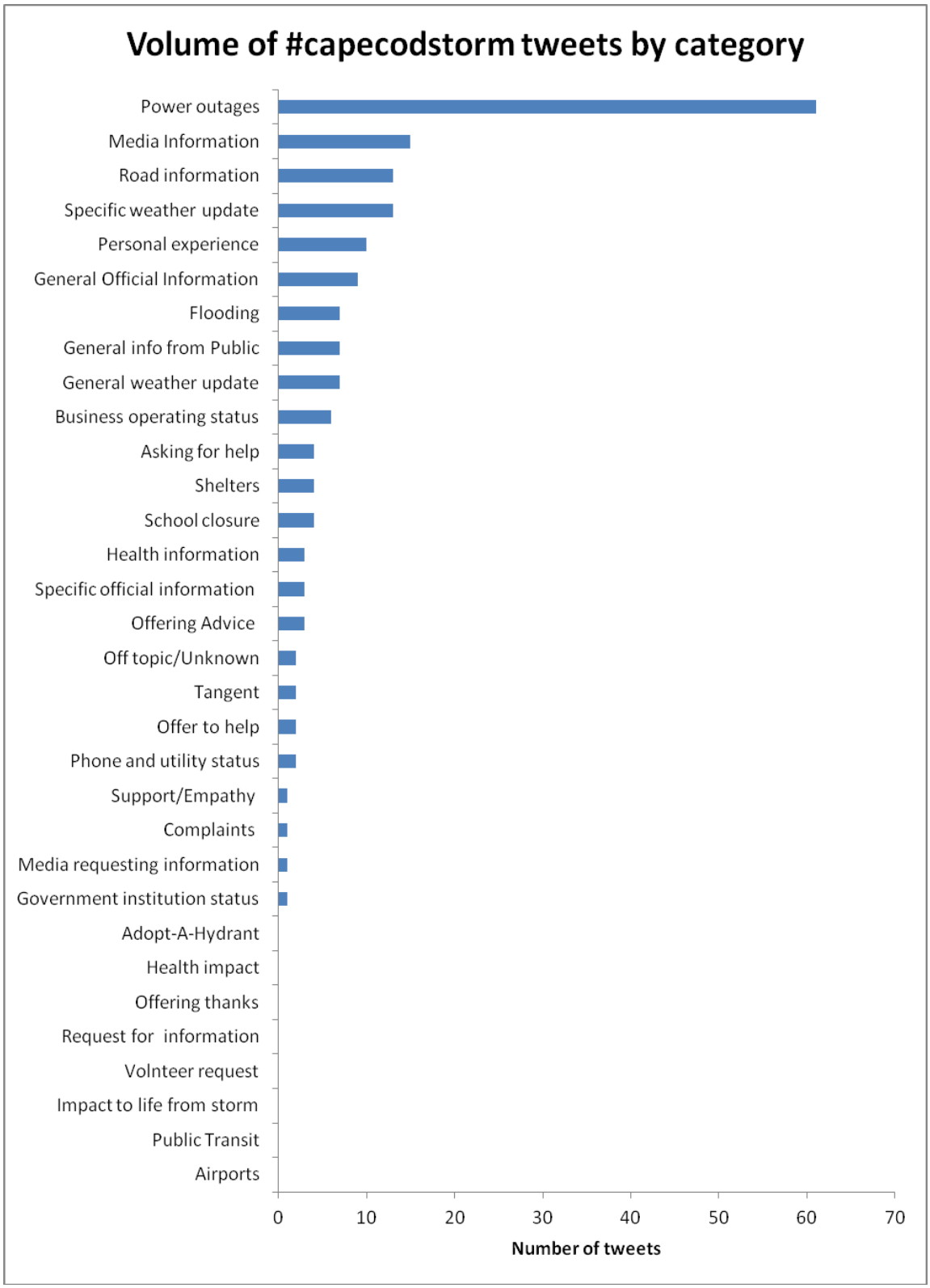

Figure 23. Volume of #capecodstorm tweets for each category

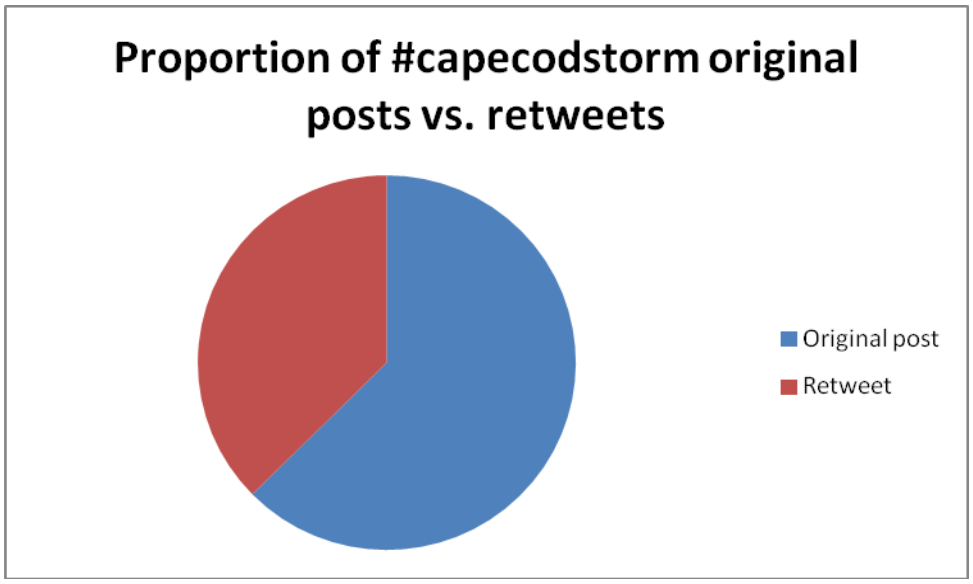

Figure 24. Proportion of original tweets and retweets

The hashtag #capecodstorm was not used heavily for tweeting information about school closures or operating status. Only approximately 3% of #capecodstorm tweets (n=4) contained information about schools. Three of the four school-related tweets were from the Cape Cod Times Twitter account (@capecodtimes), while the last was a retweet of this Cape Cod Times post, "Updated #CapeCod school closure list just posted: http://t.co/brgpnH0Y @capecodtimes #capecodstorm."[226]

Business status information was a bit more popular than school status on #capecodstorm, at just under 5% of total tweets. Once again, the Cape Cod Times was responsible for all the tweets in this category, including "We have a bunch of cancellations, early school dismissals, forecasts, emergency numbers, more http://t.co/Z9bIs9r8 #capecod #capecodstorm."[227] Sixty-six percent were original @capecodtimes tweets, and the remainder were retweets of @capecodtimes posts. Only one tweet was about government status.

Weather updates, both specific and general, were shared on #capecodstorm, much like on the other hashtags studied. Over 10% of tweets with the #capecodstorm hashtag

[226] Cape Cod Times, Twitter post, February 10, 2013, 2:28 p.m., https://twitter.com/capecodtimes.

[227] Cape Cod Times, Twitter post, February 8, 2013, 9:52 a.m., https://twitter.com/capecodtimes.

contained specific weather updates, while over 5% contained general weather updates. Over 60% of those specific updates and 100% of the general updates contained links. Over one third of the specific weather updates and just over half of the general updates were retweets. One specific update was, "A portion of Winter St. in Hyannis is closed due to trees in the road. Shiver me timbers. @capecodtimes #capecodstorm http://t.co/K8KkLy45."[228] The Cape Cod Times again dominated general weather updates. While only two posts, including "Check out this snowstorm gallery from our staff photographers http://t.co/AKCaZ6F5 #capecod #capecodstorm,"[229] came from the @capecodtimes account, when retweets are included, six out of seven posts originated from @capecodtimes.

Figure 25. Picture uploaded by @capecast, from their tweet, "A portion of Winter St. in Hyannis is closed due to trees in the road. Shiver me timbers. @capecodtimes #capecodstorm http://t.co/K8KkLy45."[230]

Information about roads was shared on #capecodstorm, with over 10% of tweets sharing roadway information. Nearly 70% of road-related tweets contained links, and

[228] CapeCast, Twitter post, February 10, 2013, 12:31 p.m., https://twitter.com/capecast.

[229] Cape Cod Times, Twitter post, February 9, 2013, 2:54 p.m., https://twitter.com/capecodtimes.

[230] CapeCast, Twitter post.

almost half were retweets. The Cape Cod Times was again a major part of tweets from the #capecodstorm hashtag in this category, as almost half of the tweets were from its account, and a few more were retweets of its posts. For example, the Cape Cod Times tweeted, "Video: Mid-Cape road conditions and interview with snowplow drivers: http://t.co/nf52CrSf @capecodtimes #capecodstorm."[231]

Official updates behaved differently from the other hashtags studied. The only tweets providing official updates were those that only provided general information. Tweets providing more specific updates were not retweeted. Also, general tweets comprised approximately 7% of the total #capecodstorm tweets, and were shared in the beginning of the storm. Specific official updates were grouped later in the event, and comprised less than 3% of all #capecodstorm tweets.

While some official advice was given on #capecodstorm, it comprised than 3% of the total tweets, with two-thirds coming from the Cape Cod Times. The Brooks Free Library posted, "MEMA: If you have property damage, document w photos or video. Check w/ insurance for coverage. Keep records of repair costs #capecodstorm."[232]

Media outlet updates were relatively common on #capecodstorm, which comprised over 12% of all tweets on the hashtag. Nearly half (47%) were retweets. Some of the most common were announcements that the online version of the Cape Cod Times was free during the storm, such as "@CapeCodTimes newspaper delivery delayed due to storm. Read our replica edition online: http://t.co/8IIzZ8cb #capecodstorm."[233]

Tweets about power status were the most common category of tweet on #capecodstorm and comprised approximately half of all posts. Over one-third of posts using this hashtag were retweets. Approximately 25% of tweets in this category were from @capecodtimes, and another 50% were either retweets of @capecodtimes posts, or were replies to that Twitter account. It was easy to get a sense of how many Cape residents were without power by reading tweets in this category, such as "UPDATE: As

[231] Cape Cod Times, Twitter post, February 9, 2013, 10:40 a.m., https://twitter.com/capecodtimes.

[232] Brooks Free Library, Twitter post, February 11, 2013, 3:22 p.m., https://twitter.com/Brooks_Free_Lib.

[233] Cape Cod Times, Twitter post, February 9, 2013, 8:57 a.m., https://twitter.com/capecodtimes.

of 11:45 p.m., 95k #capecod residents were still without power -- http://t.co/M27nVjdp @capecodtimes #capecodstorm."[234]

Mass transit was not mentioned on #capecodstorm.

People only made a few requests for help using the #capecodstorm hashtag. All these were asking for assistance to restore electrical service, including Lisa Morales, who tweeted, "@capecodtimes please send them to Robbins Cir, Dennis. No septic pump! Out since Friday eve. #capecodstorm."[235]

People did not utilize #capecodstorm for offering thanks at all, and only one complaint was posted.

Impacts to health from the storm were not reported. Three tweets contained information related to health. One was from @capecodtimes, "Cape Cod Hospital and Falmouth Hospital will be open during the storm. #capecodstorm http://t.co/AVCzeLwd,"[236] and the other two were retweets of this message.

Just one tweet expressed support for people dealing with the snowstorm, which came from Lindsey Lu, "@suecovemanser Sue do you have power? We don't, day 4. Stay safe. #capecodstorm #ivan."[237]

Unlike the #bosnow and #mastorm hashtags, fire hydrants were not mentioned by anyone using the #capecodstorm hashtag. Also, no tweets requested information.

Flooding was mentioned in approximately 6% of tweets using #capecodstorm. While three out of the seven tweets were from the Cape Cod Times, all other posts about flooding were either retweets of @capecodtimes tweets, or mentioned them by including "@capecodtimes" in their tweet. Over 40% of flooding-related tweets were retweets.

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[234] Cape Cod Times, Twitter post, February 9, 2013, 11:52 p.m., https://twitter.com/capecodtimes.

[235] Lisa Morales, ASP, Twitter post, February 10, 2013, 9:37 a.m., https://twitter.com/LisaLMorales.

[236] Cape Cod Times, Twitter post, February 8, 2013, 4:15 p.m., https://twitter.com/capecodtimes.

[237] Lindsey Lu, Twitter post, February 8, 2013, 2:34 p.m., https://twitter.com/LindseyLu1011.

Figure 26. Picture uploaded by @capecast, from their tweet, “Uncle Tim’s bridge in wellfleet almost swamped by big high tide. @capecodtimes #nemo #capecodstorm http://t.co/ZzLDqiBz.”[238]

Just over 3% of #capecodstorm tweets mentioned shelters in the Cape Cod area. The Cape Cod Times accounted for 75% of those tweets, including “Three Cape emergency shelters to open at 3 this afternoon: Sandwich HS, Nauset HS, D-Y HS http://t.co/Z9bIs9r8 #capecod #capecodstorm.”[239] No posts about shelters were retweeted.

Only one tweet contained a link with no clues about the content of the link.

Tweets using #capecodstorm were predominantly related to the topic. Just one tweet was only tangentially related, from the Brooks Free Library, “If you have power

[238] CapeCast, Twitter post, February 9, 2013, 11:06 a.m., https://twitter.com/capecast.

[239] Cape Cod Times, Twitter post, February 8, 2013, 10:40 a.m., https://twitter.com/capecodtimes.

but #capecodstorm finds you without a good book, download an e-book or audiobook with your CLAMS card.http://t.co/zlPtYL9x,"[240]

Adding personal experiences that did not also contain situational updates, as was done for #bosnow, shows that #mastorm posts were even more on-topic than #bosnow.

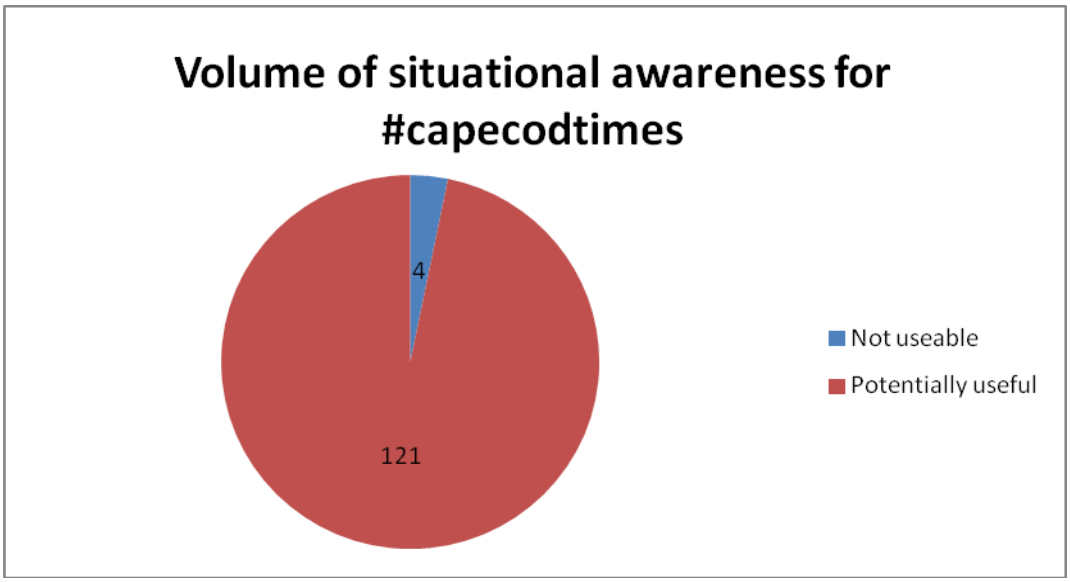

Figure 27. Amount of tweets containing some level of situational awareness

D. CASPER-SPECIFIC ANALYSIS

Following the same methodology as with #bosnow and #mastorm tweets, #capecodstorm tweets were compared with the CASPER question bank to evaluate the value of the hashtag for disaster epidemiology.

1. Identification and Physical Location

This category seeks to determine the location of the people being interviewed. Departing somewhat from the other hashtags, many posts using #capecodstorm did not contain location clues beyond the hashtag itself. While Cape Cod is home to only

[240] Brooks Free Library, Twitter post, February 9, 2013, 11:02 a.m., https://twitter.com/Brooks_Free_Lib.

approximately 220,000 year round residents,[241] it comprises over 300 square miles.[242] Tweets with #capecodstorm were less useful in providing location information than the other hashtags. However, some users did provide additional location clues, including Lisa Morales, who shared, "@NSTAR_News I'm bummed to be part of the 58% of Dennis without power. 22 hours and counting! #capecodstorm #Blizzard2013 #CapeCod."[243]

2. Demographics

The #capecodstorm hashtag contained far fewer personal updates than the other hashtags studied, but citizens still used it to report on local conditions. Similar to the other hashtags, in many cases, it could be inferred through the context of the tweet that a person did not choose to evacuate. For example, Lori Ann Higgins posted, ""That's us!RT @capecodtimes: About 28K #CapeCod #NStar customers still without power: http://t.co/o6sv27E0 @capecodtimes #capecodstorm"".[244]

Much like the other hashtags studied, #capecodstorm was not used to discuss personal evacuations due to the storm, but information about shelters was available. The Cape Cod Times, which played a nearly constant role on #capecodstorm shared, "Falmouth officials say community shelter to open at 3 pm at Falmouth High School http://t.co/Z9bIs9r8 #capecod #capecodstorm."[245]

3. Damage and Repair

This hashtag was much less useful in documenting the damage from the storm than the other hashtags studied. Information was available; however, the volume of tweets was much lower for #capecodstorm. The information available was similar to that found in the other hashtags, such as this update from @capecast, "It's not just trees that

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[241] CapeCodOnline.com, "Census: Cape Cod Losing Population," http://www.capecodonline.com/apps/pbcs.dll/article?AID=/20110323/NEWS/103230326.

[242] United States Coast Guard, "USCG Air Station Cape Cod, MA," (n.d.), http://www.uscg.mil/d1/airstaCapeCod/inboundpersonnel/area-overview.asp.

[243] Lisa Morales, Twitter post, February 9, 2013, 7:19 p.m., https://twitter.com/LisaLMorales.

[244] Lori Higgins, Twitter post, February 11, 2013, 6:49 p.m., https://twitter.com/LoriAnnHiggins.

[245] Cape Cod Times, Twitter post, February 8, 2013, 3:12 p.m., https://twitter.com/capecodtimes.

fell due to the storm. We've got road signs down on West Main St. in Hyannis. #capecodstorm http://t.co/aD46TOSx."[246]

Relative to the small amount of total tweets on #capecodstorm, flooding was a common topic. Moira Swiatkowski's tweet, ""RT @capecodtimes: Flood concerns rise in #Sandwich as high tide approaches at 10 a.m. http://t.co/KOfF2tHy @capecodtimes #capecodstorm","[247] and ""Video of flooding on River Road in #Sandwich and high tide at Town Neck Beach: http://t.co/KOfF2tHy @capecodtimes #capecodstorm","[248] from the Cape Cod Times were typical posts related to flooding.

4. General Utilities

Information about electrical power service was very prevalent on #capecodstorm, which comprised about half of all tweets studied. Reports were both personal, as evidenced by a question tweeted by Lisa Morales, "@suecovemanser Sue do you have power? We don't, day 4. Stay safe. #capecodstorm #ivan,"[249] and general to the cape area, such as this Cape Cod Times post, ""About 28K #CapeCod #NStar customers still without power: http://t.co/3y52JyQ0 @capecodtimes #capecodstorm."[250] A few of reports mentioned heat, but it was unclear whether their heat was electrical or from another type of fuel. Kristen Elise posted, "No power and no heat ..nice. #blizzard #capecodstorm http://t.co/iA5q3NQB."[251] References to other utilities, like phone or natural gas, were not found.

5. Carbon Monoxide Exposure

Unlike the #bosnow and #mastorm hashtags, no tweets discussed carbon monoxide exposure. An Internet search did not reveal any reports of carbon monoxide poisoning in the Cape Cod area during the storm. Although, the Cape did experience

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[246] CapeCast, Twitter post, February 9, 2013, 11:10 a.m., https://twitter.com/capecast.

[247] Moira Swiatkowski, Twitter post, February 9, 2013, 10:19 a.m., https://twitter.com/atlanticmoira.

[248] Cape Cod Times, Twitter post, February 9, 2013, 12:57 p.m., https://twitter.com/capecodtimes.

[249] Lisa Morales, Twitter post, February 11, 2013, 3:25 a.m., https://twitter.com/LisaLMorales.

[250] Cape Cod Times, Twitter post, February 11, 2013, 6:31 p.m., https://twitter.com/capecodtimes.

[251] Kristen Elise, Twitter post, February 9, 2013, 9:00 a.m., https://twitter.com/TheKrisMix.

widespread power outages, warnings to residents about the risks from carbon monoxide were not shared using this hashtag.

6. Animal Safety

Again, this category of questions did not really apply to a winter storm in the New England areas. Mosquitoes and other vectors are not significant problems after heavy snowfall.

7. Supplies and Relief

The hashtag #capecod storm did not offer much information about supplies and relief. Users did not use this hashtag to discuss food and water supplies. No tweets were identified that discussed businesses open to supply the public with goods. Some local shelters were mentioned, including "Three Cape emergency shelters to open at 3 this afternoon: Sandwich HS, Nauset HS, D-Y HS http://t.co/Z9bIs9r8 #capecod #capecodstorm."[252]

Information about how the storm impacted travel was available on #capecodstorm. The statewide driving ban was only mentioned in a few tweets. However, a fair amount of information was posted about local roads. Dhyana Sansoucie reported, "Out and about. Lots of trees down along 6a in sandwich - still passable. @capecodonline.com #capecodstorm,"[253] and @capecast shared, "A portion of Winter St. in Hyannis is closed due to trees in the road. Shiver me timbers. @capecodtimes #capecodstorm http://t.co/K8KkLy45."[254]

Clues about the greatest needs of local residents were not widely discussed on #capecodstorm, although a few posts indicated needs, including one from Lisa Morales, "@BostonDotCom why do I care when I have no power, heat or septic pump? Bully for them! #dennis #capecodstorm."[255]

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[252] Cape Cod Times, Twitter post.

[253] Dhyana Sansoucie, Twitter post, February 10, 2013, 12:43 p.m., https://twitter.com/dhywoo.

[254] CapeCast, Twitter post.

[255] Lisa Morales, Twitter post, February 11, 2013, 3:28 a.m., https://twitter.com/LisaLMorales.

8. Health Status

As previously mentioned, #capecodstorm was not used to share any information about the impact of the storm on the health of the population. Additionally, information that can be used to protect health was not available either.

9. Medical Care and Prescriptions

The only tweets sharing information about medical care were previously mentioned tweets noting that area hospitals would remain open during the storm, including ““RT @capecodtimes: Cape Cod Hospital and Falmouth Hospital will be open during the storm. #capecodstorm http://t.co/AVCzeLwd.”[256]

10. Communication

The hashtag #capecodstorm did offer some limited insight into information about the storm, but was much less useful than the other hashtags studied. The hashtag #capecodstorm was obviously the hashtag that local news agency, The Cape Cod Times, used to offer updates to local residents on Twitter. The Cape Cod Times dominated conversation on #capecodstorm. Fully 30% of all tweets using this hashtag originated from @capecodtimes. Another 46% of tweets using @capecodstorm were retweets of Cape Cod Times posts, or mentioned @capecodtimes in the tweet. Only about 24% of the total tweets were unrelated to the Cape Cod Times.

E. WORD CLOUD

The word cloud in Figure 28 is even more informative than that for the previous hashtags studied. As previously mentioned, tweets about power outages comprised about half of the posts studied in this chapter. It is easy to see how dominant that issue was for this hashtag. In an interesting departure from #bosnow and #mastorm, once the most frequent words are removed, as shown in Figure 29, few issues seem to come to the surface.

[256] Frank DeNauw, Twitter post, February 8, 2013, 5:21 p.m., https://twitter.com/capecodtimes.

Figure 28. Word cloud for #capecodstorm tweets[257]

Figure 29. Word cloud for #capecodstorm tweets with the most frequent words removed[258]

[257] Created using Wordle, "Wordle—Beautiful Word Clouds."

[258] Created using Wordle, "Wordle—Beautiful Word Clouds."

VI. FINAL DISCUSSION, RECOMMENDATIONS, AND CONCLUSION

This chapter begins with discussion of overall findings and recommendations for organizations seeking to implement or enhance a social media plan to improve their incident response. Concluding remarks follow the discussion and recommendations.

A. DISCUSSION AND RECOMMENDATIONS

- Public health agencies face shrinking budgets, and traditional methods of gaining situational awareness are resource intensive. Can social media be used to provide situational awareness to public health and other responders during an emergency?

This study found that Twitter activity provided a rich source of data about current emergencies and events that public health and other responders could use to increase their situational awareness. Reports of an ambulance stuck in snow, impassible roads, and unplowed streets can help responders adjust plans to a changing situation. Reports of neglected areas can help officials better provide services to their constituents. The local updates from citizens can help agencies understand which areas were impacted most heavily from the storm, particularly those tweets about damaged property and infrastructure. Learning which businesses are able to provide goods and services to the public can take some of the burden off relief agencies. The CASPER analyses conducted in this study demonstrate that many elements of a traditional RNA are available on Twitter, but it would supplement, rather than replace, a CASPER.

The City of Boston's @NotifyBoston was an example of a creative way to gain situational awareness from the public. Mayor Thomas Menino's Office of Constituent Engagement runs the account. City employees regularly responded to tweets, which provides both general information and direct answers to specific questions from constituents. Staff members of @NotifyBoston even passed information to appropriate agencies when notified of an issue via Twitter. Members of the public had a clear way to provide local updates to the Mayor's staff about roads that needed plowing or other issues

needing attention. Public health and other agencies could mimic this approach, and create a specific Twitter account designed to receive individual reports directly from the public.

In a related vein, the media made effective use of Twitter during the winter storm by requesting information from users of the platform. While most media inquiries were seeking personal stories instead of critical situational awareness, public health responders could request desired information in a similar fashion. Both @NotifyBoston and the media provided a direct way for the public to provide information. This approach could be a successful method of easily obtaining useful information from an event that generates a large volume of Twitter activity.

Information discovered from the hashtags studied can provide responders with feedback that can be used to improve their response, and adjust a tactic not working as desired. The hashtag #mastorm provided a reminder to state officials that a statewide driving ban might have been too extreme, as users posted information suggesting that the western part of Massachusetts was much less impacted than the eastern part. Boston residents also used #bosnow to mention that snow removal crews were neglecting the Jamaica Plain neighborhood.

The #openinbos hashtag demonstrates one method of how Twitter can be used by public health and other responders. Businesses and consumers used #openinbos to find and share information about establishments open in the aftermath of the snowstorm, which allowed citizens to replenish supplies, obtain meals, and enjoy some recreation during a weather event that left many people stranded in their homes. Citizens that can feed and supply themselves could lessen the burden on agency responders, which also provided responders with information about what type of services were available to the public. Public health professionals could leverage the #openinbos example, and create specific hashtags to share information more effectively. For a response with a heavy focus on vaccine, something like #vaxinbos, for example, could be used to focus local discussion on vaccine related issues in the Boston area. Such a hashtag could even be specifically tailored to provide updates on vaccine locations, or other items of interest.

While nothing forces a user to respect the intended topic of a hashtag, the analysis of

tweets in this study suggests that users predominantly follow the topic of a hashtag on Twitter.

General situational awareness was certainly available from the hashtags studied. Snowfall totals and impacts to roads were frequently reported. Electrical power status was commonly posted and retweeted. The status of schools, mass transit, and businesses was often shared using these hashtags. Twitter was able to offer quite a bit of information about the snowstorm and the impact on the communities involved. While much of this information was likely available through traditional media, tweets are to the point and easy to read quickly. Agencies could use their Twitter feeds to stay abreast quickly of important news, in addition to seeking information unavailable elsewhere.

- If social media can provide situational awareness, how can a public health agency leverage this technology with limited financial and human resources?

Crude analysis is possible without requiring any technology or equipment, beyond basic office equipment, such as a computer and Internet connection. Applications, such as TweetCharts.com, are available to assist responders in targeting their search for relevant hashtags. Public health responders can implement a program to perform surveillance on social media with very little training or additional resources.

The word clouds presented in this paper can even provide an organization with a good starting point if it wants to obtain a general sense of what is being discussed on a particular hashtag. The researcher found that downloading a series of tweets with a specific hashtag, and creating a word cloud, could be accomplished in a few minutes. Agencies should remember that a word cloud would not provide any context; therefore, the exclusive use of word clouds might make it difficult to determine if the public was positively or negatively receiving a particular topic. However, it is a simple way of generating keywords for more detailed analysis. A somewhat deeper analysis can be done by removing the most frequent words, including extraneous ones, as demonstrated in the previous chapters.

Manual review of tweets to determine what situational awareness is contained within is not an efficient process. In the short term, a list of keywords could be developed

for each type of emergency. Keyword searches would reduce the time required to perform tweet analysis, but missing important pieces of information could be a risk if the keyword list was not exhaustive. Post-event analysis could continually improve the keywords used.

For the long term, public health agencies should work with information technology experts to find ways to automate content analysis of Twitter conversations. Ultimately, it would be preferred to develop applications that can use sophisticated algorithms to classify content to allow the rapid analysis needed to allow the information contained within a hashtag to presented be quickly to incident decision makers. Even if those applications required a human to interpret the results, automated sorting could still greatly decrease the amount of time required to analyze tweets during an emergency.

Many different groups and organizations have explored software applications to analyze tweets, as discussed during the literature review. At the time of this study, none was ready for off-the-shelf use by public health and other emergency responders. The digital age has been one of rapid progress; therefore, the development of these tools should be monitored. These applications should be evaluated as they become available.

Official agencies may be releasing tweets without considering hashtag usage. A hashtag is not needed to reach an existing network of followers, but without one, agencies risk missing the opportunity to engage with other users. A service like Tweetcharts.com could be used to identify popular hashtags relating to an event, and tweets could be repeated with multiple hashtags (if all relevant tags do not fit within the 140 character limit imposed by Twitter). Using popular hashtags related to an event can help an agency increase the reach of its message, by making the posts more visible for users who do not already follow official agency social media accounts. This study found that users were likely to retweet messages that contain useful and relevant information.

Agencies that tweet during the aftermath of a disaster should use caution when drafting their messages. Although many official tweets were popular for retweeting by other users, the retweeting process adds precious characters, and many of the tweets evaluated were truncated as a result that frequently left the meaning of the tweet in

question, and sometimes shortened Internet links so that they were unusable. A good practice might be to include the most important part of the message at the beginning of the tweet to minimize content loss from truncation. Another tactic could be to use less than the allowed 140 characters, perhaps only using 120 characters, to save room for retweets.

The analysis of tweets from this storm found that links were commonly attached to postings. A cursory review found that many of these links were images. This study did not attempt to analyze images systematically from tweets relating to the snowstorm. It would be advantageous to find a solution to enable responders to view images associated with an event quickly. While text queries could be used to narrow the list of tweets down to those claiming to contain the specifically desired information (such as road conditions, for example), this analysis found numerous tweets that contained no clues as to the content of the attached images. Viewing all images associated with a large event would be as daunting as reading every tweet, even though images can convey a great deal of information. A method to categorize and view images easily and quickly would be tremendously useful to responders.

This study did not attempt to determine if the tweets were geocoded, due to limitations of data obtained using The Archivist. Exploring the use of geocoded social media posts would be useful for public health and other responding agencies. Knowing precise locations for tweets providing actionable information could allow authorities to direct resources more efficiently. Tools that can easily display tweets on a map would help responders quickly identify locations with unresolved issues.

Any new policy, technology, or process should have measures of success, and using Twitter for situational awareness is no different. Agencies should gauge the success of the program through surveys conducted after every disaster response. Feedback from incident responders is essential to determine if this new method for gaining situational awareness is providing useful information, and how it could be improved. The social media team from a public health agency should also conduct an after action review specific to the use of social media during the event. This review should seek ways to improve speed and efficiency, as well as other areas for continual improvement.

Twitter is just one of numerous social media applications. Although the public nature and short message limits make Twitter an attractive research platform, other platforms may also contain elements useful to public health and other emergency responders. It would therefore be worthwhile to explore methods to integrate these social media applications into the response effort. Additionally, MySpace offers a cautionary message about focusing efforts on just one social media platform. At one point, MySpace was the most popular social media platform in the world. However, things change quickly on the Internet, and the barriers are low for creating a competing technology. In a relatively short timeframe, Facebook was able to surpass and ultimately eclipse MySpace as the dominant social media platform.[259] Therefore, public health and other response agencies should maintain awareness of other social media platforms, and follow users if they migrate to other applications. As Figure 30 illustrates, migration on social media is not an instantaneous event, but occurs over time,[260] which should allow public health agencies plenty of time to adapt to changing preferences and technologies. A final point about emerging social media networks is that they are not mutually exclusive. Responding agencies could certainly use multiple platforms. Social media platforms should be explored as they emerge.

[259] Bloomberg BusinessWeek Magazine, "The Rise and Inglorious Fall of Myspace," June 22, 2011, http://www.businessweek.com/magazine/content/11_27/b4235053917570.htm.

[260] QBurst, "The Urgent Need for Your Business," February 23, 2011, http://blog.qburst.com/2011/02/the-urgent-need-for-your-business/.

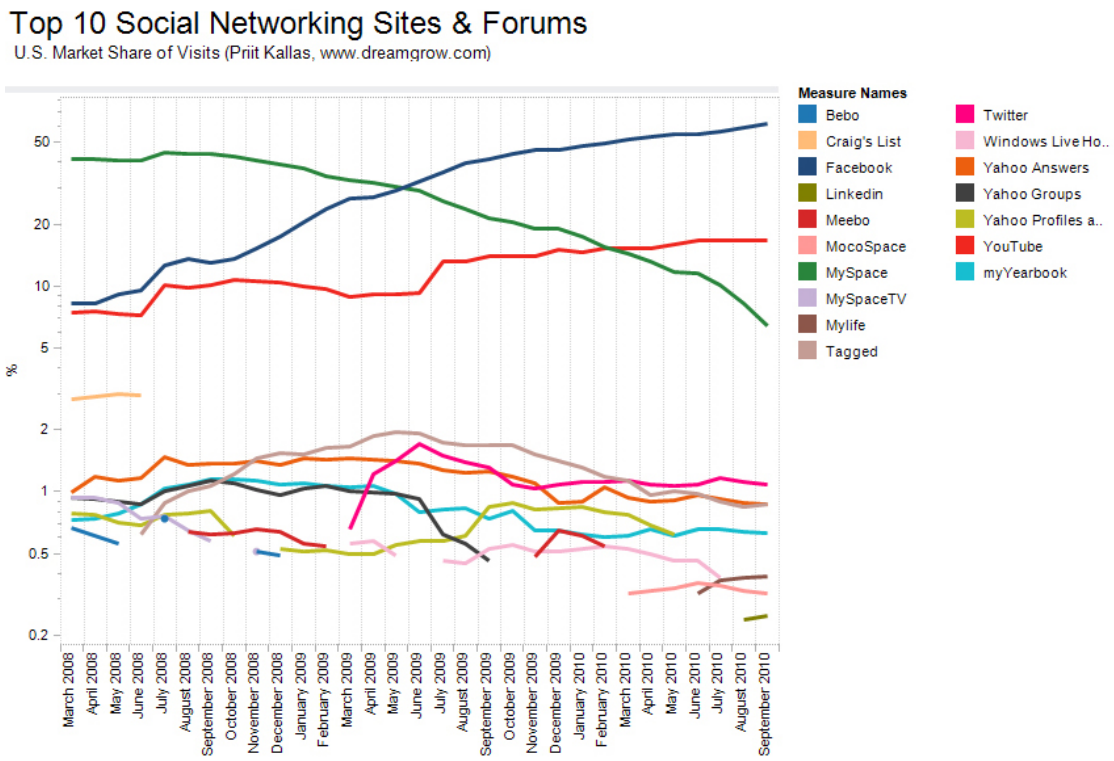

Figure 30. Top 10 social networking sites and forums

B. CONCLUSIONS

This study demonstrates that useful situational awareness is actively being posted and shared using Twitter. Social media has given amplification to the voices of ordinary citizens, which allows them to connect with emergency responders easily. However, a conversation requires more than one party. American citizens are increasingly using these social media platforms to communicate, not just with each other, but also with agencies that serve the public. Due to the increasing importance of this communication channel, it would seem irresponsive, perhaps even irresponsible, for government institutions to ignore social media.

Admittedly, the immense volume of information available on Twitter and other social media platforms can be intimidating; however, dealing with challenges is perhaps one of the few constants in the world of managing complex incident management. Tools and tactics discovered during this research and by other researchers can help a nascent agency engage their constituents. The time for emergency responders to join the social

media age has already passed, but the opportunities remain available for any organization willing to invest the time and energy.

APPENDIX

A. CAN TWITTER PROVIDE PSYCHOLOGICAL FIRST AID?

Any public health response to disaster needs to consider psychological first aid (PFA). The National Response Framework (NRF) includes mental health services in the Emergency Support Function #8, Public Health and Medical Services Annex.[261] After a typical disaster, it is likely that far more people will report psychological symptoms than physical ones.[262] According to the Minnesota Department of Health, PFA is a strategy to reduce painful emotions by providing an environment with the following features.

- Safety
- Calm & Comfort
- Connectedness
- Self-Empowerment
- Hope

PFA is designed to be useable by anyone, without a need for advanced psychological training or education.[263] It is intended to provide assistance with a victim's immediate needs, and not to treat psychological disorders.[264]

The primary weakness of psychological first aid is that it has not been rigorously evaluated by clinical trials or other controlled research studies. However, a literature

[261] FEMA, "Emergency Support Function #8–Public Health and Medical Services Annex," (n.d.), http://www.fema.gov/library/viewRecord.do?id=7359.

[262] Johns Hopkins Public Health Preparedness Programs—Johns Hopkins Bloomberg School of Public Health, "Training—Psychological First Aid Training," (n.d.), http://www.jhsph.edu/research/centers-and-institutes/johns-hopkins-center-for-public-health-preparedness/training/PFA.html.

[263] Minnesota Department of Health, "Psychological First Aid (PFA): OEP," (n.d.), http://www.health.state.mn.us/oep/responsesystems/pfa.html.

[264] Jeffrey H. Fox et al., "The Effectiveness of Psychological First Aid as a Disaster Intervention Tool: Research Analysis of Peer-reviewed Literature from 1990–2010," *Disaster Medicine and Public Health Preparedness* 6, no. 3 (2012): 247.

review commissioned by the Advisory Council of the American Red Cross Disaster Services found widespread agreement among professionals that the tactic was effective and appropriate for untrained providers.[265]

Social media may offer the ability to deliver psychological first aid to affected areas in the aftermath of a disaster. Social media technology allows people to interact regardless of location. Most social media applications are free of charge and relatively easy to use. Additionally, social media platforms like Twitter, which limits posts to 140 characters, have been shown to be resilient. A key advantage of Twitter is that the low bandwidth of a short message will often be delivered on an overloaded or damaged cell network, while a phone call may not.[266]

A study of a series of natural disasters in New Zealand and Australia in 2011 found evidence that social media can assist in delivering psychological first aid. Through a survey, respondents indicated that they felt connected and useful by using social media during the incident.[267]

The Veteran's Administration and the National Child Traumatic Stress Network jointly developed the Psychological First Aid Field Operations Guide (hereafter referred to as The Guide), which is designed to guide responders of various backgrounds through the process of delivering PFA. The guide outlines eight core actions of PFA.[268]

- Contact and Engagement
- Safety and Comfort
- Stabilization
- Information Gathering: Current Needs and Concerns

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[265] Fox et al., "The Effectiveness of Psychological First Aid as a Disaster Intervention Tool: Research Analysis of Peer-reviewed Literature from 1990–2010," 247.

[266] A. Mills, R. Chen, J. Lee, & H. R. Rao, "Web 2.0 Emergency Applications: How Useful Can Twitter Be For Emergency Response?" *Journal of Information Privacy & Security* 5, no. 3 (2009): 3–26, http://search.proquest.com/docview/203667040?accountid=12702.

[267] Mel Taylor et al., "The Role of Social Media as Psychological First Aid as a Support to Community Resilience Building," *The Australian Journal of Emergency Management* 27, no. 1 (2012): 20–26.

[268] United States Department of Veterans Affairs, National Center for PTSD, "Psychological First Aid: Field Operations Guide," (n.d.), http://www.ptsd.va.gov/professional/manuals/psych-first-aid.asp.

- Practical Assistance
- Connection with Social Supports
- Information on Coping
- Linkage with Collaborative Services

To test the hypothesis that social media applications can provide effective PFA, an analysis was performed using data collected for this study. Tweets from the #bosnow hashtag were compared to the elements of PFA as described in The Guide.

B. CONTACT AND ENGAGEMENT

- Goal: To respond to contacts initiated by survivors, or to initiate contacts in a non-intrusive, compassionate, and helpful manner.

The Guide advises, "Even a brief look of interest and calm concern can be grounding and helpful to people who are feeling overwhelmed or confused."[269]

Analysis of #bosnow tweets revealed that Twitter users offered empathy and support for residents affected by the massive snowfall. Posts were both personal in nature, such as "good to hear! "@SimmonsCollege: How is everyone doing? We made it through the night safe+sound and now we're just waiting it out! #bosnow,"[270] and more general in nature, like "Thinking of you #boston from #atlanta! #nemo #bosnow with @catherinvaritek http://t.co/h9P1SIEb".[271] Support of this nature was offered throughout the recovery from the storm.

Additionally, some examples of people initiating contact were evident, which could provide an opening for responders to provide assistance. An example was "@amabe421 I'm determined to trek about outside, even if its for a few minutes today. Going stir crazy! #bosnow,"[272]

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[269] United States Department of Veterans Affairs, National Center for PTSD, "Psychological First Aid: Field Operations Guide," 23.

[270] Whole Foods Symphony, Twitter post.

[271] Elkman, Twitter post.

[272] Rachel, Twitter post.

C. SAFETY AND COMFORT

- Goal: To enhance immediate and ongoing safety, and provide physical and emotional comfort.

The Guide mentions several issues to address under this function, the first of which is to ensure immediate physical safety. Tweets with the #bosnow hashtag contained information that citizens could use to keep themselves safe and healthy, such as clearing the exhaust before operating vehicles to prevent carbon monoxide poisoning, including "2 killed from CO poisoning in Boston post- #nemo Clear exhaust pipes of vehicles and home furnace vents http://t.co/5JDpunkr #bosnow."[273] Another element of ensuring immediate safety in The Guide is to encourage survivors to contact relatives. Analysis found some tweets providing reminders that the elderly may need assistance, like "RT @ONEin3: Not everyone in #Boston is a ONEin3er! Know any elderly neighbors who cld use some help shoveling?? #InstantKarma #BoSnow".[274] Tweets of this nature were widely retweeted, which increases visibility of the message.

The next item mentioned in The Guide to enhance safety and comfort is to provide information about the disaster response, what to do next, and available services. A wealth of information about the response effort was present in the tweets studied. Tweets gave situational updates, such as the extent of power outages, information about shelters, efforts to plow roadways, and what businesses and institutions (such as schools and city hall) were operational. People were urged to remain off the roads to allow authorities to clear snow.

Another suggestion from The Guide in this section is to encourage social engagement. Using a hashtag like #bosnow on Twitter provides a forum for people to share and discuss how the storm was impacting their lives. A large portion of the tweets from this hashtag was from people posting pictures of the amount of snow in their immediate area.

[273] Noah Reiter, Twitter post, February 9, 2013, 7:41 p.m., https://twitter.com/noahreiter.

[274] Kelly, Twitter post.

A final item in this section where social media has been proven useful is to help survivors who have missing family members. While missing people were not a part of the tweets studied, examples appear in the literature about the use of social media for families and others to update each other on their status. After the 2010 Haiti earthquake, residents used Facebook and Twitter to communicate their status, which was particularly effective in areas in which phone lines were unavailable.[275]

D. STABILIZATION (IF NEEDED)

- Goal: To calm and orient emotionally overwhelmed or disoriented survivors.

The Guide mentions that most people affected by disasters will not need stabilization, which is intended for victims with obvious signs of being overwhelmed or disoriented. Social media may not be directly useful in this regard. However, tweets on #bosnow urged people to check in on friends or family that might need help. If that advice is heeded, those individuals could provide assistance. Further research would be needed to claim the utility of social media for this activity.

E. INFORMATION GATHERING: CURRENT NEEDS AND CONCERNS

- Goal: To identify immediate needs and concerns, gather additional information, and tailor Psychological First Aid interventions.

This activity involves an effort to understand the scope of an individual's experience, and customize the intervention to those needs. Since Twitter is primarily an open platform for anyone to view, it may not be an appropriate vehicle for this type of personal conversation. However, Twitter does allow private, direct messaging between two users, so it would be possible for a public health agency to survey individuals privately to understand their specific needs. Research would be needed to demonstrate the effectiveness of this intervention.

[275] Christopher Lawrence Slagh, "Managing Chaos, 140 Characters at a Time: How the Usage of Social Media in the 2010 Haiti Crisis Enhanced Disaster Relief," *Georgetown University*, 2010, https://repository.library.georgetown.edu/handle/10822/553585.

F. PRACTICAL ASSISTANCE

- Goal: To offer practical help to survivors in addressing immediate needs and concerns.

Numerous examples of tweets used the #bosnow hashtag, which offered ways to obtain practical assistance. As noted in The Guide, when people obtain needed resources, they can offer them hope and empowerment.[276] One tweet offered, "#Barnstable PD says area residents who need shelter should go to Cape Cod Hospital, where Nat'l Guard will help find the closest one #bosnow."[277] Another tweet offered, "If you need help, or have neighbors who need assistance, get in touch with/follow @OccupyNemo. #Nemo #Bosnow."[278] Even more specific was this offer, "#Quincy is offering to drive people to shelter. Call 617 376 1105 #bosnow."[279]

Another form of practical assistance after a severe snowstorm is helping people find food and supplies from vendors able to open their doors. The hashtag #openinbos spontaneously emerged in the aftermath of Nemo. Users gravitated to this hashtag to discover and share information about businesses able to open despite the massive snow accumulation. Over 75% of the tweets provided information about Boston-area businesses open during the storm, and many of the rest were notices of business closures or inquiries about open businesses. User @andrav23 retweeted "RT @tplepage: Shaws at the Pru is #openinBOS until 5:00 PM. Long lines though and may not find what you need. @universalhub http://t.co ..."[280]

G. CONNECTION WITH SOCIAL SUPPORTS

- Goal: To help establish brief or ongoing contacts with primary support persons and other sources of support, including family members, friends, and community helping resources.

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[276] United States Department of Veterans Affairs, National Center for PTSD, "Psychological First Aid: Field Operations Guide."

[277] Erin Ailworth, Twitter post, February 10, 2013, 9:06 a.m., https://twitter.com/ailworth.

[278] alex pearlman, Twitter post, February 9, 2013, 9:11 a.m., https://twitter.com/lexikon1.

[279] Quincy on Boston.com, Twitter post.

[280] Andrea, Twitter post.

As previously mentioned, social media including Twitter has been used to help families and friends locate each other after a disaster. Additionally, Twitter in particular was shown to be functional when other modes of communication were damaged.

Another suggestion from The Guide is to encourage people to lean on those who are available when loved ones are not around. Many forms of support mentioned in The Guide were displayed on #bosnow tweets and include emotional support, social connection, advice and information, physical assistance, and material assistance. Tweets with these attributes have been discussed in previous sections.

H. INFORMATION ON COPING

- Goal: To provide information about stress reactions and coping to reduce distress and promote adaptive functioning.

While the primary goal of this suggestion is to offer basic coping mechanisms, The Guide also notes that providing survivors with certain types of information can help them manage stress and problems more effectively. Many examples of this information were observed on #bosnow and have been previously discussed. This information includes current situational awareness, available services, and how authorities are trying to help.

I. LINKAGE WITH COLLABORATIVE SERVICES

- Goal: To link survivors with available services needed at the time or in the future.

This suggestion is designed to encourage and personally assist someone to seek needed assistance. As discussed previously, the public nature of Twitter makes it less useful for personal discussions. Other than offering impersonal recommendations for services like shelters, this behavior was not noticed with #bosnow tweets.

J. CONCLUSION AND RECOMMENDATIONS

Users of the #bosnow hashtag demonstrated many elements of psychological first aid. While Twitter does not present itself as an ideal platform for all facets of PFA, it does offer some advantages that make it attractive for offering some portion of the

assistance. For one, the service is free of charge, with the exception of staff time. Therefore, as long as a public health agency has an effective policy with which to manage social media use, capital investment is not required to begin using the service.

Another reason to continue to evaluate delivering PFA via Twitter and other social media is that it may allow agencies to reach citizens in remote areas. Wildfires often affect broad areas of land in remote areas, which makes it difficult for responders to provide traditional services. Social media has already demonstrated utility for providing public health services, such as injury surveillance to remote areas.[281]

As this study demonstrates, users on Twitter, without prompting or involvement of emergency planners, are already providing many facets of PFA. This tendency should be explored. Agencies should continue to develop skills in the effective use of social media to engage with citizens in their jurisdictions. Support and information should be frequently offered via Twitter after an event.

Pre-event planning is another area of importance for PFA. Although not part of this study, PFA also involves providing information to citizens before a disaster on how people can protect themselves if an event does occur.[282] Many public health and other emergency response organizations are already using Twitter to provide preparedness information to citizens in their jurisdictions.[283]

Confidentiality regulations, such as the Health Insurance Portability and Accountability Act (HIPAA), probably prohibit the delivery of all PFA services via Twitter. The public nature of the platform makes it inadvisable for professionals to solicit personal information from users. However, many facets of PFA are well matched for a platform such as Twitter. Providing information, including how to access PFA care in person, can easily be done using social media.

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[281] Cinnamon and Schuurman, "Injury Surveillance in Low-resource Settings Using Geospatial and Social Web Technologies," 25.

[282] Adrienne Stith Butler, Allison M. Panzer, and Lewis R. Goldfrank, eds., *Preparing for the Psychological Consequences of Terrorism: A Public Health Strategy* (The National Academies Press, 2003), http://www.nap.edu/openbook.php?record_id=10717.

[283] Author's observation from personal Twitter use.

One limitation of this evaluation is that it does not evaluate the effectiveness of PFA provided by Twitter. It would be useful for future research to examine case studies examining any potential differences between survivors who used social media applications like Twitter and those who did not.

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LIST OF REFERENCES

Achrekar, Harshavardhan, Avinash Gandhe, Ross Lazarus, Ssu-Hsin Yu, and Benyuan Liu. "Predicting Flu Trends Using Twitter Data." In *2011 IEEE Conference on Computer Communications Workshops (INFOCOM WKSHPS)*, 2011.

American Red Cross. "More Americans Using Mobile Apps in Emergencies." August 31, 2012. http://www.redcross.org/news/press-release/More-Americans-Using-Mobile-Apps-in-Emergencies.

Aulov O., and M. Halem. "Human Sensor Networks for Improved Modeling of Natural Disasters." *Proceedings of the IEEE* PP, no. 99 (2012): 1–12.

Bayleyegn, Tesfaye Sanchez, National Center for Environmental Health (U. S.), and Division of Environmental Hazards and Health Effects. *Community Assessment for Public Health Emergency Response (CASPER) Toolkit Hausman, Leslie*. Atlanta, GA: Centers for Disease Control and Prevention, National Center for Environmental Health, Division of Environmental Hazards and Health Effects, Health Studies Branch, 2009.

Bhat, F. M., K. Challis Oussalah, and T. Schnier. "A Software System for Data Mining with Twitter." In *2011 IEEE 10th International Conference on Cybernetic Intelligent Systems (CIS)*, 2011.

Birregah, Babiga, Tony Top, Charles Perez, Eric Chatelet, Nada Matta, Marc Lemercier, and Hichem Snoussi. "Multi-layer Crisis Mapping: A Social Media-Based Approach." In *2012 IEEE 21st International Workshop on Enabling Technologies: Infrastructure for Collaborative Enterprises (WETICE)*, 2012.

Bloomberg BusinessWeek Magazine. "The Rise and Inglorious Fall of Myspace." June 22, 2011. http://www.businessweek.com/magazine/content/11_27/b4235053917570.htm.

Boston Business Journal. "Mayor Menino Apologizes for Streets Still Clogged with Snow After Nemo." February 12, 2013. http://www.bizjournals.com/boston/blog/mass_roundup/2013/02/boston-mayor-menino-apologizes-nemo.html.

Boston.com. "Historical Snowstorm Yes, Blizzard No—Weather Wisdom." February 11, 2013. http://www.boston.com/news/weather/weather_wisdom/2013/02/historical_snowstorm_yes_blizz.html.

Boulos, Maged N. Kamel, Bernd Resch, David N. Crowley, John G. Breslin, Gunho Sohn, Russ Burtner, William A. Pike, Eduardo Jezierski, and Kuo-Yu S. Chuang. "Crowdsourcing, Citizen Sensing and Sensor Web Technologies for Public and Environmental Health Surveillance and Crisis Management: Trends, OGC Standards and Application Examples." *International Journal of Health Geographics* 10, no. 1 (December 21, 2011): 67.

Boulos, Maged N. Kamel, Matthew Scotch, Kei-Hoi Cheung, and David Burden. "Web GIS in Practice VI: a Demo Playlist of Geo-mashups for Public Health Neogeographers." *International Journal of Health Geographics* 7, no. 1 (July 18, 2008): 38.

Bruns, Axel, and Jean E. Burgess. "Local and Global Responses to Disaster: #eqnz and the Christchurch Earthquake." Conference Paper. *Disaster and Emergency Management Conference, Conference Proceedings*, 2012. http://anzdmc.com.au/proceedings.pdf.

Bruns, Axel, Jean E. Burgess, Kate Crawford, and Frances Shaw. "#qldfloods and @QPSMedia: Crisis Communication on Twitter in the 2011 South East Queensland Floods." Report. *ARC Centre of Excellence for Creative Industries and Innovation; Creative Industries Faculty; Institute for Creative Industries and Innovation; Journalism, Media & Communication*, January 10, 2012. http://eprints.qut.edu.au/48241/.

Business Insider. "The Real History of Twitter." April 13, 2011. http://www.businessinsider.com/how-twitter-was-founded-2011-4.

———. "Twitter." August 2, 2010. http://www.businessinsider.com/twitter-abbreviations-2010-8.

Butler, Adrienne Stith, Allison M. Panzer, and Lewis R. Goldfrank, eds. *Preparing for the Psychological Consequences of Terrorism: A Public Health Strategy*. The National Academies Press, 2003. http://www.nap.edu/openbook.php?record_id=10717.

Cape Cod Today. "Cape Cod Bruised and Battered by Winter." February 9, 2013. http://www.capecodtoday.com/article/2013/02/09/17048-cape-cod-bruised-and-battered-winter-storm.

CapeCodOnline.com. "Census: Cape Cod Losing Population." http://www.capecodonline.com/apps/pbcs.dll/article?AID=/20110323/NEWS/103230326.

Cat's Pyjamas. "Social Media Use in a Crisis–#eqnz–Which Hashtag Prevails?" September 4, 2010. http://www.cats-pyjamas.net/2010/09/social-media-use-in-a-crisis-eqnz-which-hashtag-prevails/.

Chew, Cynthia. “Pandemics in the Age of Twitter: A Content Analysis of the 2009 H1N1 Outbreak.” *T-Space, University of Toronto Research Repository*, December 16, 2010. https://tspace.library.utoronto.ca/handle/1807/25454.

Cinnamon, Jonathan, and Nadine Schuurman. “Injury Surveillance in Low-resource Settings Using Geospatial and Social Web Technologies.” *International Journal of Health Geographics* 9, no. 1 (May 24, 2010): 25. doi:10.1186/1476-072X-9-25.

City of Worcester, Massachusetts. “Adopt-A-Hydrant.” http://www.worcesterma.gov/dpw/seasonal-information/adopt-a-hydrant.

Collier, Nigel, Nguyen Son, and Ngoc Nguyen. “OMG U Got Flu? Analysis of Shared Health Messages for Bio-surveillance.” *Journal of Biomedical Semantics* 2, no. Suppl 5 (2011): S9.

Corley, Courtney D., Diane J. Cook, Armin R. Mikler, and Karan P. Singh. “Text and Structural Data Mining of Influenza Mentions in Web and Social Media.” *International Journal of Environmental Research and Public Health* 7, no. 2 (February 2010): 596–615.

Emergency Management. “Funding Cuts Threaten Public Health Preparedness.” (n.d.). http://www.emergencymgmt.com/health/Funding-Cuts-Threaten-Public-Health.html.

Eysenbach, Gunther. “Infodemiology: Tracking Flu-Related Searches on the Web for Syndromic Surveillance.” *AMIA Annual Symposium Proceedings 2006* (2006): 244–248.

FEMA. “Emergency Support Function #8–Public Health and Medical Services Annex.” (n.d.). http://www.fema.gov/library/viewRecord.do?id=7359.

Fox, Jeffrey H., Frederick M. Burkle Jr, Judith Bass, Francesco A. Pia, Jonathan L. Epstein, and David Markenson. “The Effectiveness of Psychological First Aid as a Disaster Intervention Tool: Research Analysis of Peer-reviewed Literature from 1990–2010.” *Disaster Medicine and Public Health Preparedness* 6, no. 3 (2012): 247.

Google. “Google Flu Trends | United States.” (n.d.). http://www.google.org/flutrends/us/#US.

Heinzelman, Jessica, and Carol Waters. United States Institute of Peace. *Crowdsourcing Crisis Information in Disaster-affected Haiti*, Variation: Special Report, October 2010.

Heinzelman, Jessica, and United States Institute of Peace. *Crowdsourcing Crisis Information in Disaster-affected Haiti Waters, Carol*. Special Report. Variation: Special Report. Washington, DC: U.S. Institute of Peace, 2010.

Hidgon, Rob. “Geotagging Your Photos–The Phototripper Podcast.” *The Phototripper Podcast*, September 8, 2012. http://phototripper.net/geotagging-your-photos/.

Huang, Cheng-Min, Edward Chan, and Adnan A. Hyder. “Web 2.0 and Internet Social Networking: A New Tool for Disaster Management?—Lessons from Taiwan.” *BMC Medical Informatics and Decision Making* 10, no. 1 (October 6, 2010): 57. doi:10.1186/1472-6947-10-57.

Huffington Post, The. “Boston Blizzard: Northeast Snowed in As ‘Nemo’ Barrels Through.” February 10, 2013. http://www.huffingtonpost.com/2013/02/09/boston-blizzard-nemo_n_2650592.html.

Huiji, Gao, G. Barbier, and R. Goolsby. “Harnessing the Crowdsourcing Power of Social Media for Disaster Relief.” *IEEE Intelligent Systems* 26, no. 3 (June 2011): 10–14.

Johns Hopkins Public Health Preparedness Programs—Johns Hopkins Bloomberg School of Public Health. “Training—Psychological First Aid Training.” (n.d.). http://www.jhsph.edu/research/centers-and-institutes/johns-hopkins-center-for-public-health-preparedness/training/PFA.html.

Lampos, V., and N. Cristianini. “Tracking the Flu Pandemic by Monitoring the Social Web.” In *2010 2nd International Workshop on Cognitive Information Processing (CIP)*, 2010.

Liu, Yong, Pratch Piyawongwisal, Sahil Handa, Liang Yu, Yan Xu, and Arjmand Samuel. “Going Beyond Citizen Data Collection with Mapster: A Mobile+Cloud Real-Time Citizen Science Experiment.” In *2011 IEEE Seventh International Conference on e-Science Workshops (eScienceW)*, 2011.

MacEachren, A. M., A. Jaiswal, A. C. Robinson, S. Pezanowski, A. Savelyev, P. Mitra, X. Zhang, and J. Blanford. “SensePlace2: GeoTwitter Analytics Support for Situational Awareness.” In *2011 IEEE Conference on Visual Analytics Science and Technology (VAST)*, 2011.

Masslive.com. “Massive Snowstorm Nemo Drops 2 Feet of Snow on Northeast.” February 9, 2013. http://www.masslive.com/news/index.ssf/2013/02/massive_snowstorm_nemo_drops_2.html.

———. “Winter Storm Nemo Buries Western Massachusetts in Snow, but Fails to Reach ‘Blizzard’ Level in Pioneer Valley.” February 9, 2013. http://www.masslive.com/news/index.ssf/2013/02/region_recovers_from_non-blizz.html.

———. “Winter Storm Nemo Knocks out Power to 375,000-plus in Massachusetts.” February 9, 2013. http://www.masslive.com/news/index.ssf/2013/02/winter_storm_nemo_knocks_out_p.html.

McGee, Matt. “With 400 Million tweets Per Day, Twitter Spending ‘Inordinate Resources’ On Improving Content Discovery.” June 7, 2012 at 2:33pm ET. http://marketingland.com/twitter-400-million-tweets-daily-improving-content-discovery-13581.

Mills, A., R. Chen, J. Lee, and H. R. Rao. “Web 2.0 Emergency Applications: How Useful Can Twitter Be For Emergency Response?” *Journal of Information Privacy & Security* 5, no. 3 (2009): 3–26. http://search.proquest.com/docview/203667040?accountid=12702.

Minnesota Department of Health. “Psychological First Aid (PFA): OEP.” (n.d.). http://www.health.state.mn.us/oep/responsesystems/pfa.html.

MIX Online. “The Archivist Desktop by Mix Online.” (n.d.). http://visitmix.com/work/archivist-desktop/.

Nakaji, Yusuke, and Keiji Yanai. “Visualization of Real-World Events with Geotagged Tweet Photos.” In *2012 IEEE International Conference on Multimedia and Expo Workshops (ICMEW)*, 2012.

Nielsen Wire. “Smartphones Account for Half of All Mobile Phones, Dominate New Phone Purchases in the US.” (n.d.). http://blog.nielsen.com/Nielsenwire/online_mobile/smartphones-account-for-half-of-all-mobile-phones-dominate-new-phone-purchases-in-the-us/.

ProQuest. “Web 2.0 Emergency Applications: How Useful Can Twitter Be For Emergency Response?” (n.d.). http://search.proquest.com.libproxy.nps.edu/docview/203667040/1390C6822A774753B01/8?accountid=12702.

QBurst. “The Urgent Need for Your Business.” February 23, 2011. http://blog.qburst.com/2011/02/the-urgent-need-for-your-business/.

Queensland University of Technology. “#qldfloods and @QPSMedia: Crisis Communication on Twitter in the 2011 South East Queensland Floods | QUT ePrints.” January 24, 2012. http://eprints.qut.edu.au/48241/.

Schein, Rebecca Keelan, Peel (Ont.), and Peel Public Health, *Literature Review on Effectiveness of the Use of Social Media a Report for Peel Public Health / Wilson, Kumanan*. Brampton, Ont.: Region of Peel], Peel Public Health, Saint-Lazare, Quebec: Canadian Electronic Library, 2011.

Shoaf, Kimberley I., and Steven J. Rottman. “Public Health Impact of Disasters.” *Australian Journal of Emergency Management* 15, no. 3 (2000): 58–62.

Slagh, Christopher Lawrence. “Managing Chaos, 140 Characters at a Time: How the Usage of Social Media in the 2010 Haiti Crisis Enhanced Disaster Relief.” *Georgetown University,* 2010. https://repository.library.georgetown.edu /handle/10822/553585.

St Louis, Connie, and Gozde Zorlu. “Can Twitter Predict Disease Outbreaks?” *British Medical Journal* 344, no. 7861 (June 16, 2012). http://search.proquest.com.lib proxy.nps.edu/docview/1026778819/1388766D1B65F085D96/101?accountid=12 702.

Szomszor, M., P. Kostkova, and C. St. Louis. “Twitter Informatics: Tracking and Understanding Public Reaction During the 2009 Swine Flu Pandemic.” In *2011 IEEE/WIC/ACM International Conference on Web Intelligence and Intelligent Agent Technology (WI-IAT),* 2011.

Taylor, Mel, Garrett Wells, Gwyneth Howell, and Beverley Raphael. “The Role of Social Media as Psychological First Aid as a Support to Community Resilience Building.” *The Australian Journal of Emergency Management* 27, no. 1 (2012): 20–26.

Texas Department of State Health Services. “Community Assessment for Public Health Emergency Response (CASPER).” (n.d.). http://www.dshs.state.tx.us/commprep/ disasterepi/casper/intro.aspx.

Thackeray, Rosemary, Brad L. Neiger, Amanda K. Smith, and Sarah B. Van Wagenen. “Adoption and Use of Social Media Among Public Health Departments.” *BMC Public Health* 12, no. 1 (March 26, 2012): 242.

Tweet Archivist. “Tweet Archivist Desktop.” (n.d.). http://www.tweetarchivist.com /archivist-desktop/.

United States Coast Guard. “USCG Air Station Cape Cod, MA.” (n.d.). http://www.uscg. mil/d1/airstaCapeCod/inboundpersonnel/area-overview.asp.

United States Department of Health and Human Services, National Institute of Health, National Institute of Deafness and Other Communication Disorders (NIDCD). “What Is Epidemiology?.” (n.d.). https://www.nidcd.nih.gov /health/statistics/Pages/epidemiology.aspx.

United States Department of Veterans Affairs. National Center for PTSD. “Psychological First Aid: Field Operations Guide.” (n.d.). http://www.ptsd.va.gov/professional/ manuals/psych-first-aid.asp.

Van Leuven, Laurie J. “Optimizing Citizen Engagement during Emergencies through Use of Web 2.0 Technologies.” *DTIC Online,* March 2009. http://stinet.dtic.mil/ oai/oai?&verb=getRecord&metadataPrefix=html&identifier=ADA497269.

Weather Channel, The. “Winter Storm Nemo: Snow, Wind, Coastal Flood Reports.” February 13, 2013. http://www.weather.com/news/weather-winter/winter-storm-nemo-reports-20130208.

Wordle. “Wordle—Beautiful Word Clouds.” (n.d.). http://www.wordle.net/.

Yin, J., A. Lampert, M. Cameron, B. Robinson, and R. Power. “Using Social Media to Enhance Emergency Situation Awareness.” *IEEE Intelligent Systems* PP, no. 99 (2012): 1.

Zhu, Jiang, Fei Xiong, Dongzhen Piao, Yun Liu, and Ying Zhang. “Statistically Modeling the Effectiveness of Disaster Information in Social Media.” In *2011 IEEE Global Humanitarian Technology Conference (GHTC)*, 2011.

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