

Online Public Communications by Police & Fire Services during the 2012 Hurricane Sandy

Amanda L. Hughes¹, Lise A. St. Denis², Leysia Palen², Kenneth M. Anderson²

¹Department of Computer Science
Utah State University
Logan, UT
amanda.hughes@usu.edu

²Project EPIC
University of Colorado Boulder
Boulder, CO
{lise.st.denis, palen, kena}@colorado.edu

ABSTRACT

Social media and other online communication tools are a subject of great interest in mass emergency response. Members of the public are turning to these solutions to seek and offer emergency information. Emergency responders are working to determine what social media policies should be in terms of their “public information” functions. We report on the online communications from all the coastal fire and police departments within a 100 mile radius of Hurricane Sandy’s US landfall. Across four types of online communication media, we collected data from 840 fire and police departments. Findings indicate that few departments used these online channels in their Sandy response efforts, and that communications differed between fire and police departments and across media type. However, among the highly engaged departments, there is evidence that they bend and adapt policies about what constitutes appropriate public communication in the face of emergency demands; therefore, we propose that flexibility is important in considering future emergency online communication policy. We conclude with design recommendations for making online communication media more “listenable” for both emergency managers and members of the public.

Author Keywords

crisis informatics; disaster; emergency; microblogging; risk communication; social computing; social media

ACM Classification Keywords

H.5.3 Groups & Organization Interfaces—collaborative computing, computer-supported cooperative work

INTRODUCTION

With their need to quickly reach and engage with a diffuse target audience, emergency service workers are reportedly adopting social media and other online communication tools to connect with the public they serve [3,8,9,12,19].

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than ACM must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from Permissions@acm.org.

CHI 2014, April 26 - May 01 2014, Toronto, ON, Canada
Copyright 2014 ACM 978-1-4503-2473-1/14/04...\$15.00.
<http://dx.doi.org/10.1145/2556288.2557227>

Based on our ongoing research in this area, however, we see that use is uneven, and policy and practice with respect to such use are not always aligned. Studies have documented how members of the public use online communications like social media in a variety of emergency contexts [7,9,13,16,18,20,26], and emergency workers appear to be attending to that demand though seem uncertain about how to respond. The social media audience that emergency managers earnestly build and prepare in-between emergencies may find themselves frustrated when those same managers struggle to meet the online communication demand if a disaster were to happen.

What remains empirically unknown is how widespread online media use is for emergency public information communication, and what the nature of that use is. Existing studies in this area have been limited to examining emergency workers who are heavily engaged in these communications [3,12]—mostly because it is easier to find and study traces of their activity—rather than examining the absence of online communications.

This research attempts to provide a more comprehensive description of how and why much emergency services use online media to communicate with the public during mass emergencies by examining fire and police departments’ use during Hurricane Sandy. In a disaster event like Hurricane Sandy—one that affected millions of people and required a massive coordinated response and recovery effort—information needs are great. We examine the activities of fire and police agencies during this event because both play significant roles in the distribution of emergency preparedness, response, and recovery information to the public during and after large-scale disasters [24].

Background Literature

A small but growing area of crisis informatics research [6,17] examines online media use by emergency responders, and reports on their typically slow adoption of such tools [9]. Emergency responders are trained in formal command-and-control protocols for managing emergencies and it is rarely clear how to integrate social media and other online tools effectively into these existing, formal procedures [2,8]. Additionally, organizational support for online communication with the public is often lacking, with limited resources, insufficient management support, poor

tools, and no training [8,12]. Further, the volume of public information surrounding an event can be challenging to monitor and online sources can be difficult to identify and verify, especially in large-scale events [8].

Prior work has expounded upon some of the features of online communication by emergency personnel. Early adopters of social media in some organizations are seen as evangelists: A public information officer (the public relations representative of an emergency response organization) from the Los Angeles Fire Department [12] has influenced how his and other fire departments might use online tools like social media to retrieve intelligence and communicate with constituents. Other research examines how a wildfire response team incorporated vetted virtual volunteers to help offload the work required to deal with a fairly high volume of social media activity by the public [19]. Another study [22] examined how state and federal organizations used Twitter around the 2010 Deepwater Horizon oil spill and discovered that social structures created through Twitter affected the way information spread. More recently, Deneff et al. examined Twitter use of two police departments during the 2011 London Riots, and described the different styles of public engagement that each assumed—one more formal and detached (instrumental) and the other more informal and personal (expressive) [3]. Though these studies reveal particular uses as well as uncertainty about how to incorporate social media into emergency practice, they do not provide a representative picture of how online communications like social media are used in a general emergency response context.

In this paper, we seek to fill this knowledge gap by studying fire and police public communications before, during, and directly following Hurricane Sandy. Specifically, we examine the communications across four types of online media by departments in the path of the storm.

STUDY SITE AND DATA COLLECTION

Hurricane Sandy

On October 29, 2012 Hurricane Sandy made landfall at Brigantine, New Jersey, in one of the most densely populated regions of the United States (US). Hurricane Sandy was the deadliest hurricane (with 72 direct deaths) to strike the east coast in over forty years, and the second-costliest hurricane (estimated at \$65 Billion US dollars [15]) in US history [1]. The storm displaced approximately 776,000 people [25] and damaged or destroyed over 650,000 homes [1]. During the storm, nearly 8.5 million people lost power with outages lasting weeks in the more heavily impacted areas [1].

Several factors complicated the response to Hurricane Sandy. First, the impact of the hurricane was intensified by an existing winter storm system: a phenomenon known as the Fujiwhara effect [4] that caused the two storms to merge into one “superstorm.” Second, despite dire predictions

from forecasters of extreme weather and a potentially lethal storm surge, a survey conducted after the event indicates that approximately 63% of residents in coastal areas chose not to evacuate [5]. Finally, a large winter storm—termed a Nor’easter—moved into the affected area a week later, causing additional difficulty for Sandy recovery efforts, especially for those still without shelter and/or power.

Data Collection & Analysis Methods

The data collection began with specification of a geographical boundary that included those hardest hit by the storm, with a scope that allowed for analytical breadth: we included coastal counties within a 100 mile radius of where Sandy made landfall as the target (see Figure 1). This made for a total of 26 counties located across 5 US states.



Figure 1: 100-mile radius centered on Brigantine, NJ, where Sandy made US landfall on October 29, 2012

Fire and Police Department Identification

Next, we identified all fire and police departments within the 26 counties. We extracted a list of fire departments from the National Fire Department Census Database. Unfortunately, the US Fire Administration reports that only 88% of departments participated. However, we discovered that counties sequentially assign numbers to fire departments. This rule of thumb helped identify gaps in the census data, and revealed an additional 75 departments—bringing the total sample to 568 fire departments.

The police departments exist at three levels: state, county, and municipality. Each of the 5 states has a state police department, and each of the 26 counties has a sheriff's office. Additionally, every municipality (e.g. township, city, and village) can potentially have a police department. We found online lists of all the municipalities in the 26 counties, and performed a web search for their respective departments, identifying a total of 272 police departments.

Data Retrieval from the Four Online Communication Media

For each fire and police department, we looked at four online communication media: a website, a subscriber-based notification service (Nixle), a microblogging service (Twitter), and a social networking service (Facebook). Though we found occasional references to other online communication tools such as Google+ and CodeRed, these were rarely used and not included in the study.

We searched for a website for each of the departments; if found, we captured the URL and then examined its content for references to social media accounts. In addition, we then looked for Nixle, Twitter, and Facebook accounts using their search interfaces. In Nixle, searching by municipality returns all accounts in that area. In Twitter and Facebook we searched using the departments' names and variations. If through due diligence we did not find an account, we assumed it either did not exist or could not be found easily by members of the public either, thus defeating any purpose of its use as a communication medium.

To narrow the scope to those online communications most likely to be about Hurricane Sandy, we restricted the data collection window to October 25-November 9, 2012. On October 25, the first online Sandy communication appeared in our datasets. By November 9, most of the immediate hurricane recovery efforts had completed and the number of online communications that were not about Hurricane Sandy began to outnumber those that were.

Website. Because each fire and police department website is unique and the information is presented in different ways, we were unable to collect data in a format that would allow for comparison to the other types of online communication. However, we visited and made notes for 676 websites; these sites often linked to the other media, described next.

Nixle. This online service offers both free and paid notification services to fire and police departments as well as other emergency management and municipal government agencies. Users can search for agencies by location and subscribe for notifications. We found 128 Nixle accounts and extracted the post information for each of these accounts using web-scraping methods. In a few cases, some of the older data for these accounts had been deleted. The *Fire & Police Nixle Collection* contains 930 posts.

Twitter. We found 114 Twitter accounts and retrieved the full message streams for each of these accounts using the Twitter REST API. The *Fire & Police Sandy Tweet Collection* contains 3033 tweets.

Facebook. We identified 556 public Facebook accounts and retrieved the full set of posts for each of these accounts using the Facebook Graph API. The *Fire & Police Sandy Facebook Collection* contains 4652 posts.

Content Coding

We coded the data for on/off-topicness and content. The final coding scheme contains 19 categories (see Table 1) and was developed through an iterative pair-coding process. The first coding pass was done with two researchers working together to establish a consistent coding scheme on the Twitter data. After this first pass, we consolidated and refined the categories and then took a second pass on the data to correct and verify the coding scheme. Next, we divided the Facebook and Nixle coding tasks between the same two researchers. To check the validity of this independent coding process, both researchers coded a

subset of 200 messages. For this subset, Cohen's kappa across the 19 coding categories averaged 0.87 (SD = 0.24).

Category	Description
cleanup	Clearing of hurricane debris
closures	Closure/re-opening of public offices, transportation services, access routes, and scheduled events
damage	Storm damage information
donations	Donations of time (volunteering), money, or supplies to relief efforts
engagement	Invitations to engage with department on social media or direct responses to public posts/tweets
evacuation	Evacuation order and shelter information
preparation	Storm preparation information
protocol	Formal response protocol information (e.g. when to call 9-1-1 versus 3-1-1)
reassurance	Reassurance to the public that first responders are prepared for or actively monitoring the storm
reference	Reference to an external information source
relief	Storm assistance or relief information
response	Specific incidents or response efforts during the hurricane
resources	Information about supplies needed or available
rumor	Misinformation and rumor
safety	Safety precautions or conditions
services	Power, phone, internet, or cable services information
status	Changing storm condition information
support	Expression of gratitude or support
weather	Weather updates

Table 1: Nixle, Twitter, Facebook Content Coding Scheme

Level of Engagement

Lastly, we developed a coding scheme to compare engagement levels for each department across Nixle, Twitter, and Facebook (Table 2). We did not code websites for engagement because data collection occurred months after Hurricane Sandy, at which point it was difficult to know what information the website had contained during our data collection window.

Level	Description
Inactive	No account found OR account found but not used
Non-Sandy Active	Account used to share information, but not used to share information about Hurricane Sandy
Sandy Active	Account used to communicate information about Hurricane Sandy

Table 2: Engagement Level Coding Scheme

QUANTITATIVE DESCRIPTIONS OF USE

Overall Online Communication Use

Results indicate (Figure 2) that the majority of departments have a website (81%) and/or a Facebook account (66%). Twitter use, however, was much less common (13%) and Nixle differs greatly by type of department (police: 40%, fire: 3%, combined: 15%). In general, the percentage of departments that have a website or social media account was higher for police than fire (Figure 3), with the exception of Facebook: 70% of fire departments and 60% of police departments have Facebook accounts.

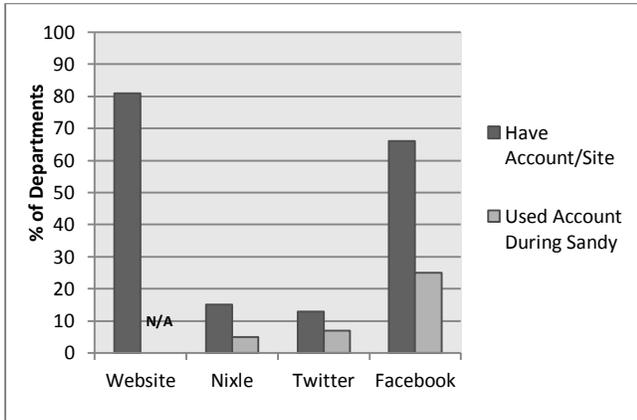


Figure 2: % Departments with Accounts/Website versus the % That Used Their Account during Sandy

Even though a fire or police department may have a website and/or a social media account, they did not necessarily use it to communicate during Hurricane Sandy. Figure 3 shows the smaller percentage of departments that used each communication medium to engage in storm-specific communication with the public: Facebook (25%) is the most popular, followed by Twitter (7%), and finally, Nixle (5%). We do not report website use because we could not collect reliable data around its use during Hurricane Sandy.

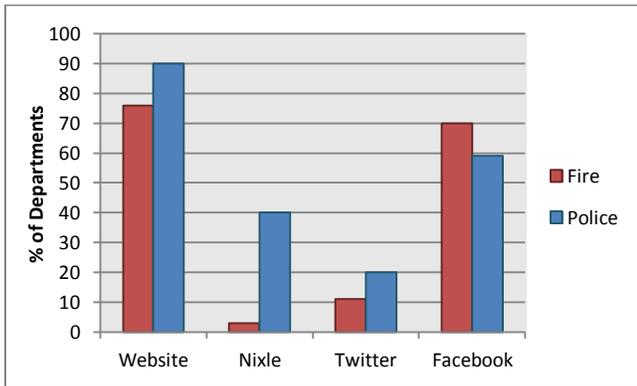


Figure 3: % of Fire and Police Departments Using Each Communication Medium

Figure 4 shows how frequently each content category occurs in the Facebook, Twitter, and Nixle message collections. The number of messages is averaged across the number of active accounts for each communication type. Twitter averages are higher overall for each of the categories except *reference*. The opposite is true for Facebook where the averages are mostly lower. The most frequently occurring categories are information about *closures*, *reference* to other official sources of information, *safety* instructions, and *weather* updates.

The *reference* category, which describes those cases when third party sources are discussed, is important because it shows that emergency managers operating social media accounts often play an information vetting role, sifting through available information and sharing what they think

is relevant with their constituents. Usually these references point to sources from other agencies, especially those with a broad jurisdiction or scope of interest such as a state governor’s office, the Federal Emergency Management Agency (FEMA), or the US National Weather Service.

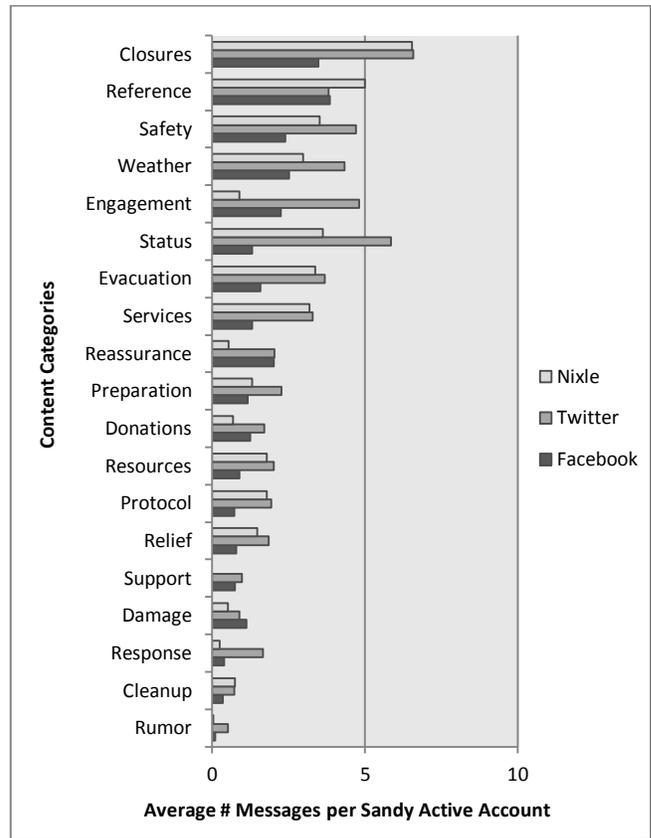


Figure 4: Average Number of Messages per Active Account for Each Content Category for Nixle, Twitter, and Facebook

Interestingly, we found few instances of *rumor*, where departments corrected misinformation through their online communications. A frequent concern that emergency response organizations have with the public’s online communication is with the credibility and accuracy. These findings suggest that the presence of online rumor is not as much of an issue as some may fear.

Each of the four online communication media have characteristics that make them suited to different styles of communication and different ways of sharing information during an emergency. We now turn our attention to how fire and police departments used each.

Website-Specific Communication Behavior

Fire and police departments primarily used their websites as a place to provide information about themselves and information relevant to their community, but with little to no means for two-way engagement with their constituents. The information most commonly found on fire and police department websites includes employee rosters, phone numbers, links to other local agency websites, surveys of

equipment and resources, and a narrative about the department’s history. Sandy-relevant information on these websites includes warnings to prepare for the storm, fundraising activities, long-term recovery information, and accountings of department response efforts (e.g. number of calls or number of rescues). One feature used for posting information about Sandy was a blog or a blog-type feature with time- and date-stamped updates. Often these updates provided a feedback mechanism where members of the public can comment, but this feature is rarely used.

Nixle-Specific Communication Behavior

Even though Nixle is free to both fire and police departments, it was primarily used by police departments: 40% of the police departments in our sample had a Nixle account whereas only 3% of fire departments had an account. This disparity may be due to differences in role for these two organizations during an emergency event. The police communicate with the public about evacuations, closures, and safety conditions, whereas firefighters tend to focus on response to highly-localized circumstances such as administering emergency medical services or responding to a structure fire—activities that may not need to be shared with a wide audience.

Nixle provides a subscription-based, one-way channel to members of the public who want to receive notifications. Unlike a website, Facebook, or Twitter account, Nixle accounts are authenticated before creation, so members of the public have a reasonable expectation that emergency notifications they receive are from real agencies. Because Nixle can only distribute information (with no means for the public to comment or respond), the notification messages tend to read like formal press releases—carefully crafted using official and more impersonal language.

Twitter-Specific Communication Behavior

Twitter is the least frequently occurring account type. Of the 88 Twitter accounts, we found only 58 communicated information about Hurricane Sandy. The percentage of use among police departments is higher than fire departments both for having an active Twitter account (15% for police vs. 8.3% for fire) and for using it during Hurricane Sandy (10% for police vs. 5% for fire).

The majority of tweets broadcast information to the public and 66% of these messages contain links to information sources such as National Weather Service bulletins, official disaster declarations, status updates, evacuation maps, and internally compiled information. Also appearing are retweets (17%) that originate from other official sources, such as high-ranking political officials (e.g., a governor or mayor) or emergency response organizations (e.g., FEMA). Through these (re)tweets, departments performed an information vetting role during Hurricane Sandy.

Figure 5 shows the average number of categorized Twitter messages per Sandy-active account. Here we see that police departments report far more *closures*, *status* messages, and

information about *evacuations* than fire. These categories seem to speak more directly to the nature of police work, where they are expected to manage the population and maintain order during and after a disaster. The broadcast nature of Twitter can help distribute information as circumstances around an event change.

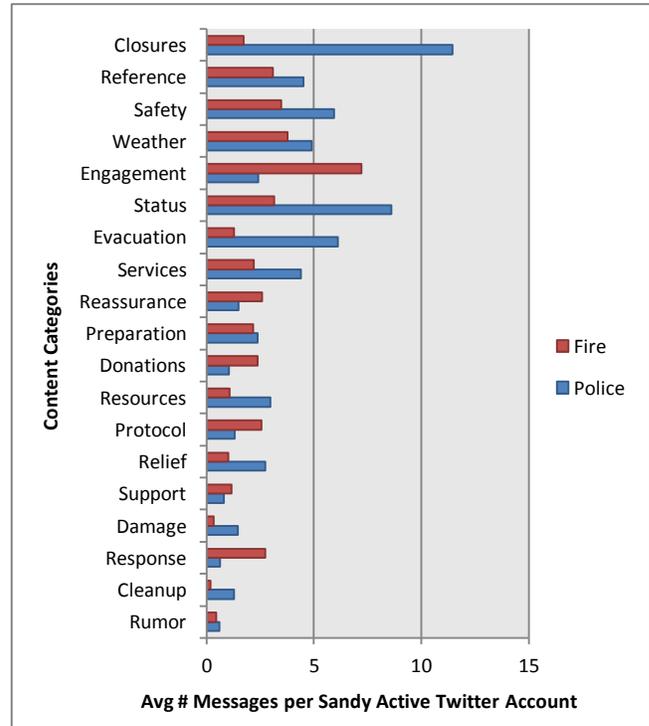


Figure 5: Fire and Police Department Tweets by Category

Surprisingly, only 9% of on-topic tweets in the *Fire & Police Tweet Collection* contain hashtags related to Hurricane Sandy (e.g. #Sandy, #frankenstorm, #HurricaneSandy). We expect to see heavier hashtag use as it is known to improve the searchability of tweets. This low incidence of common hashtags suggests that fire and police departments may depend more on Twitter’s follower relationship to reach their constituents, rather than on providing searchable terms for a general audience.

Facebook-Specific Communication Behavior

Facebook is the most widely used online medium to share information with the public about Sandy. Twenty-five percent of the departments in the sample used Facebook, which is 3.6 times the number of Twitter accounts, and five times the number of Nixle accounts. Facebook differs from the other tools that we studied in that it allows for direct and visible interaction with the public. People can post relevant questions, share information, and provide feedback. The format also allows for direct and readily visible replies, and it collates a lot of information in one place and over time. These qualities seem to make Facebook an effective tool for managing public conversation and maintaining a visible presence with the communities that fire and police departments serve.

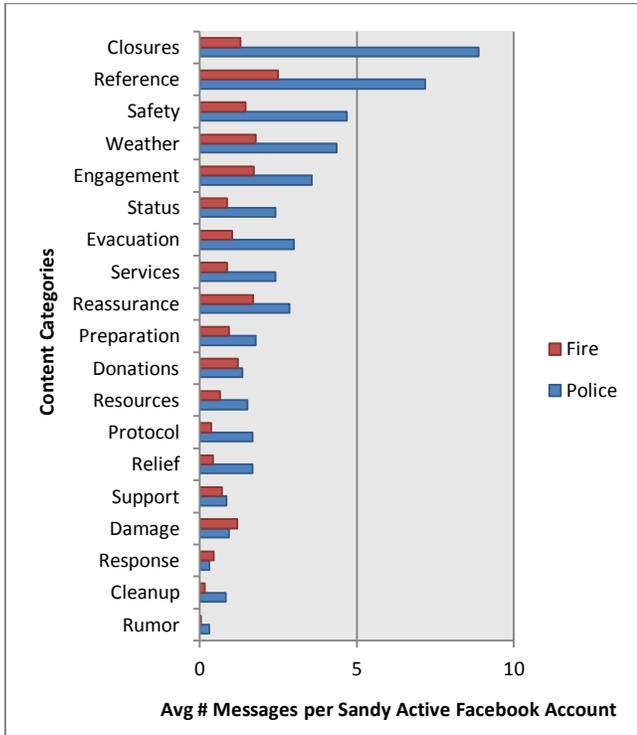


Figure 6: Average Number of Facebook Messages for Each Content Category for Fire and Police

Facebook has a similar category distribution to that of Twitter (Figure 6). The main quantitative difference is in the number of departments that replied directly to the public. With respect to the departments that used Facebook to communicate Sandy-specific information, 39% replied directly to the public whereas only 10% of the departments that used Twitter replied directly to Sandy-specific tweets and all but one of these replied sparingly (3 or less replies).

ONLINE ENGAGEMENT

To better measure and compare the varied use of online communication during Hurricane Sandy, we assigned each department an engagement level (Inactive, Non-Sandy Active, Sandy Active) for Nixle, Twitter, and Facebook. Figure 7 shows that departments were least engaged with Nixle: 90% were *Inactive*, 6% were *Non-Sandy Active*, and only 4% were *Sandy Active*. Engagement with Twitter was only slightly higher, with 89% *Inactive*, 4% *Non-Sandy Active*, and 7% *Sandy Active*. The highest levels of online engagement were found on Facebook, with 52% *Inactive*, 23% *Non-Sandy Active*, and 25% *Sandy Active*. When we calculate the percentage of *Sandy Active* accounts in all Active accounts (*Non-Sandy Active* and *Sandy Active*), Nixle is again the lowest (40%), but Twitter (63.6%) and Facebook (47.9%) are reversed. These percentages indicate that of the departments with active accounts, those that used Twitter were most likely to use it during Hurricane Sandy.

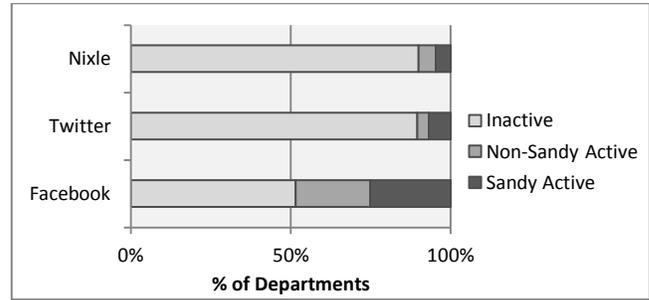


Figure 7: Department Engagement by Media Type

Next, we divided the departments into three groups based on the highest level of engagement each had. Departments at the lowest level, the *Inactive Group* (387 departments, 46.1%), include those that were *Inactive* across all three communication media. Departments in the *Non-Sandy Active Group* (207 departments, 24.6%) used at least one online medium, but did not use any media to share Sandy-specific information. The *Sandy Active Group* (246 departments, 29.3%) used at least one online medium to share Sandy-specific information. Figure 8 captures the number of active accounts per department within the *Non-Sandy Active* and the *Sandy Active* groups.

Engagement Groups	Number N of Online Media			% of Depts
	N=1	N=2	N=3	
Non-Sandy Active	88.4%	11.1%	0.5%	24.6%
Sandy Active	77.6%	19.1%	3.3%	29.3%

Figure 8: Breakdown of Non-Sandy and Sandy Active Groups by the Number of Media with that Level of Engagement

Inactive Group: The majority of departments in this group (232 departments, 60%) had no Nixle, Twitter, or Facebook account. Past studies report [8] that common reasons for emergency responders not to use online media include feeling inexperienced or lacking the time, resources, and/or approval from management. Other emergency responders perceive that online media do not meet the communication needs of their organization and community [8]. We suspect these reasons explain much of the lack of activity by departments in the *Inactive Group*.

The remainder of departments in the *Inactive Group* (155 departments, 40%) had at least one online account, but the account was clearly in disuse. This lack of account activity may be explained by departments that started to use an online account only to discover that it did not meet their needs, or they found that they did not have the time or other resources to maintain it.

Non-Sandy Active Group: These departments showed frequent and recent activity over at least one online communication medium, but curiously this did not translate into use during Hurricane Sandy. One likely reason may be that departments were so busy responding to the disaster event that online communications were not possible given the circumstances. For instance, some of the departments

most affected by the storm were incapacitated with severe flooding, power outages, and loss of vehicles, equipment, and even life. Unfortunately, the data collected in this study cannot answer questions about *why* departments did (or did not) use online communications; answers to these questions requires further data collection and study.

Sandy Active Group: Even though the percentage of department type in the *Sandy Active Group* is about the same (28% fire and 32% police), we saw a clear difference in the average number of messages when comparing police and fire. Police departments post more actively on average across all three platforms. This difference is the most pronounced on Facebook where the average number of Sandy-specific posts is 2.66 times higher for police compared to fire (32 posts versus 12). The average number of relevant tweets is 1.75 times higher when comparing police to fire. The results for Nixle are inconclusive because there are so few fire departments (4) using Nixle to which we could compare police departments.

All the online communications we collected come from those departments in the *Sandy Active Group*, so naturally we can report more on their activity and online communication practice. We now turn our attention to the departments in this group for insight into the adaptability of online tools to meet the needs of emergency response.

HIGH-ENGAGEMENT IS A SITUATED PRACTICE

When examining departments in the *Sandy Active Group*, we find a mix of communication strategies and behaviors, but most interesting are those moments when we see fundamental changes in communication that show how situated practice trumps pre-planned policy and greatly affects the shaping of public information. What constitutes appropriate online interaction evolves as both emergency personnel and the public calibrate their expectations. We illustrate this point through two examples: one excerpt taken from the activity of the Long Beach Township Police Department Facebook account, and another from the @FDNY (Fire Department of New York) Twitter account.

Long Beach Island (LBI), New Jersey, is a barrier island that suffered extensive damage during Hurricane Sandy. Residents were evacuated prior to the storm surge, and the island remained closed to residents for 13 days except for a few brief periods when they were allowed to retrieve personal belongings. These circumstances produced a situation where the LBTPD was left to protect the property interests, safety, and information needs of a displaced and often frustrated population.

The LBTPD's Facebook page served as a public forum for displaced residents to comment on the response efforts. Posts from residents fell across several themes: questions and comments about re-entry details, requests for information about damage to particular neighborhoods and properties, concerns about protection of property, and expressions of gratitude. For example:

(November 2 13:04): Any information from on the first street Loveladies Bay side ?

(November 4 14:42): When will access to north beach be allowed?

(November 2 14:42): thank you so much for keeping us informed. Can we bring any food, water, etc to donate to those who are working on the island?

By posting to a public and persistent forum like Facebook, residents hold the LBTPD publically accountable—and the LBTPD allows itself to be held accountable in turn.

LBTPD answered questions in succinct messages using formal language and without referring directly to the posters, sometimes with multiple answers in one reply. For instance, LBTPD responded to residents' questions with the following post:

LBTPD: There is no time frame for access to north beach. Any donations would be graciously accepted! Contractors can register at WWW.LBIEOC.org

They did not publicly respond directly to posts that criticize evacuation procedures or that were not beneficial to the larger population. This is another behavioral feature of mutual accountability on a public stage.

Despite LBTPD's impersonal posting style and carefully crafted responses, it was clear that the LBTPD monitored comments. For example, residents post:

(October 29 12:22): Our home is in Loveladies 117c LBB. Are there any photos from that area or news? Thank you

(October 30 8:27): Does anyone have any information about conditions in North Beach Haven @ 18th Street? Thank you first responders!

In response, LBTPD provided before and after photos for each of the neighborhoods in the township and surrounding areas. Numerous requests would have been time-consuming to respond to individually, but by posting aerial photos, the LBTPD was able to respond to broad area concerns.

As recovery efforts continue, increasingly frustrated residents offered public commentary about restricted access to their homes:

(November 5 15:23pm): No one knows my property better than I do, so why the hell am I going to call some contractor or plumber that I don't even know to enter my house to winterize or enter my house! Plus they don't have keys! To make matters worse my house is in north beach and not allowed to enter today. I want answers! Additional damages are now the townships responsibilities!

Even in response to concerns like these, the LBTPD continued to communicate in highly visible and documentable ways. In these examples, we see how the responsibilities of public communication shift in response to the situation at hand and toward mutual accountability on a public stage.

Another exchange we learn from comes from FDNY's Twitter communications. The @FDNY account generated far more tweets than other accounts and responded to members of the public more as well (179 replies to 239 accounts). The disproportionately high level of public engagement found in the @FDNY Twitter account seems to be due to several factors. The @FDNY has a potential audience of 8,175,133 people [23], which is much larger than any other fire department we examined. This account is also staffed with full-time social media personnel and has a history of replying to public inquiries. In addition, at the height of the storm surge when there were widespread power and phone outages as well as a large neighborhood fire (the Breezy Point fire) the 911-dispatch system became overloaded. Members of the public began tweeting requests for emergency assistance when they were unable to reach 911 dispatch [11]. We detail these exchanges below.

On October 28, a day prior to Hurricane Sandy landfall, @FDNY sent several (re)tweets notifying the public of evacuation orders and procedures for emergency assistance:

@FDNY¹ (Oct 28 11:56): RT @NotifyNYC: NYC orders MANDATORY EVACUATION Zone A, Rockaways, Hamilton Bch, City Is. due to dangerous storm <http://t.co/D10EV04p> or 311

@FDNY (Oct 28 16:11): RT @NYCMayorsOffice: Mayor: If you can't evacuate yourself and need assistance, please call 311. #Sandy

The next day, on October 29 as the storm surge reaches its peak, we see the first direct response to twitterers who provided emergency information and made requests:

@Lochald (Oct 29 20:03): IDK address. And he's not replying right now (probably saving his cell battery). He had said others were aware & getting help. @edaro @FDNY

A reply from @FDNY redirected him to make a 911 call:

@FDNY (Oct 29 20:06pm): @Lochald @edaro Please don't tweet with emergency info. We want to help everyone as soon as we can. Please ask him to call 911.

A tweet about the protocol for how to request help and report other information followed soon after:

@FDNY (Oct 29 21:32): PLEASE NOTE: *Do not* tweet emergency calls. Please call 911. If it is not an emergency, please call 311. #NYC #Sandy

Shortly after this message, however, @FDNY sent numerous replies indicating that they were attempting to contact dispatchers on twitterers' behalf. In the exchange that follows, we begin to see @FDNY change its stance about what constitutes appropriate Twitter protocol under these emergency circumstances:

@Dynb (Oct 29 22:12): @FDNY my sis family at 78th St155-22 Howard Beach Queens NY 11414, water risinig 12 ft need help 7186745977,1st floor drowned, kids scared

@FDNY responded:

@FDNY (Oct 29 22:16): @Dynb Please keep trying to call 911. I will try to reach dispatchers now.

A status update from @FDNY:

@FDNY (Oct 29 22:32): @Dynb Please note dispatchers are aware and are trying to send help.

From @Dynb a few hours later the following is posted:

@Dynb (Oct 30 0:08): @FDNY Thank you , water rescding but help required many many kids in neighborhood very scared & stranded 155-22 78th st, Queens 11414

A reply from @FDNY provided reassurance:

@FDNY (Oct 30 0:11): @RSDynb I understand. Dispatch was notified. I know it's difficult, but please be patient. Units working to respond to all calls safely.

In reaction to these types of exchanges, a flurry of tweets from the public appeared with expressions of concern that @FDNY was bypassing official protocol. @FDNY replied:

@FDNY (Oct 30 0:23): @Bleymor @Lisar @twitter @rass Don't want NYC to rely on this as an alt to 911. But notifying dispatchers of all emergencies tweeted

These conversations continued throughout the storm and the Breezy Point fire. Replies went back and forth as @FDNY gathered information and relayed it to dispatchers. Numerous @FDNY tweets provided reassurance that information had been received and that help was on the way. At the same time, @FDNY keeps reinforcing the use of official channels, making it clear that Twitter as dispatch was not a permanent solution but one that had become necessary given the extenuating circumstances. This observed activity had a deeply engaging quality because of implicit admission that mass emergency response is a largely improvised [10,14], or situated [21], activity.

It is unclear how this bypass of official protocol affected dispatch work or how those who "kept to the rules" and reported their emergencies through 911 were affected. However, we believe that this *public* adaptation of online communication technology is novel, and shows how protocols in disaster response are often overruled [10,14]. Rarely are such overrides so visible to the public, which is a new contribution of the online world. It is highly doubtful that this behavior will be isolated to this one emergency and to these accounts. That such popular accounts for a populous region made these moves sets a precedent and indicates what is likely to come in future events.

CONCLUSION

In this paper, we provide quantified evidence of both the presence and absence of online communications by fire and

¹ Individual usernames are anonymized while public entities' names remain unchanged.

police departments during Hurricane Sandy. Results show that relatively few of these departments used online media in their public communications during this event, and that there was a high degree of variance across the different media under study. Among those departments that used online media during Hurricane Sandy, discursive moves signal creative adaptations and set meaningful precedents for the future of emergency management.

Procedures & Policy

Emergency responders strive to implement common organizational structures and procedures to streamline coordination in multiagency response. However, no current standardized procedures exist for online media use and we argue that this is just as well. Given this research, we believe that implementing universal, and therefore likely restrictive, online media policies is premature and possibly even dangerous at this point of time in the socio-technical evolution of disaster response. Not only do online media support different kinds of interaction and purpose, emergency managers need to be free to improvise their practice in relation to the situations they and their constituents face. High-level policy decisions may prematurely mandate and restrict which media emergency groups use and how they use it.

Though some regularity is helpful—particularly in the case of warning messaging—the fluctuating needs of the public and the capacities that responders have as disasters then ensue must be matched by the communications media that support informational exchange—whether or not that includes online media. Future policies must provide flexibility that allows emergency organizations to employ strategies that best fit the needs of their organization, community, and response effort.

Transparency & Public Accountability

In the data, we see regular reminders of emergency response’s accountability to the public. Throughout the hurricane event, *reassurance* messages assert that response efforts are under control, and that professionals are in place to do the jobs for which they are trained. Evidence of this accountability is found in the information that departments provide about the status of the storm, recovery, and relief efforts. Cases of rumor correction appear, although not frequently, indicating that the amount of rumor that people mistakenly take seriously is not high; nevertheless, attention to rumor demonstrates a commitment to both social media as a meaningful communication venue that the public attends to, and to ensuring that its contents are accurate. Making good use of this transparency through public communication and the accountability that follows can be challenging, but has the potential to foster trust and lead to better decision-making by affected constituents.

In the past, reports of emergency response activities were not as freely available (e.g. they were filtered through the media, or reported in press releases every 12 hours). Communications enabled by online media can provide a

greater sense of transparency, one where emergency service workers can directly communicate with the public and one where the communications of these workers are visible to the public in ways not previously possible. Both the LBTPD and FDNY adjusted their information strategies in response to members of the public. Yet, in the case of LBTPD, this transparency also exposed the department to increased public scrutiny and criticism.

Design Recommendations & Future Work

Based on this research, we offer several design recommendations. First, to make online media streams more “listenable” for on-the-ground emergency managers, new features and/or tools are needed that allow emergency managers to better track, respond to, and document public information. For example, no automated means exist for tracking the status of online queries from the public (e.g. whether a reply was given, what the the reply was, how and when the reply was sent, who sent it, and to whom the reply was sent). Without tracking this kind of information, questions from the public can easily slip through the cracks, especially during a large-scale crisis event. Second, there is also a need to make online media streams more “listenable” for members of the public. In Twitter and Facebook, the data showed that replies by emergency managers to questions from the public were often buried within response threads to individual messages. Unless one knows what to search for or wades through many potentially irrelevant conversations, he or she may never find the information they seek, even though it is publically available. If emergency managers and members of the public could better “listen” to online media streams, value of the online media and therefore their use would likely increase during times of crisis.

To complement these technology design efforts, emergency management practice will need to create better capacities for departments to use online media. This involves finding a balance between a department’s desire to communicate online (by virtue of establishing accounts and audience following during non-disaster times) and their (in)ability to act on those relationships when personnel resources become taxed during disaster.

Low overall use of online media by fire and police departments during Hurricane Sandy suggests that emergency management use of these media is not well understood. Indeed, little research exists around the features and affordances of online media and how each can fit into an emergency management communication strategy. The research presented here lays a foundation for future applied and basic research in this area by reporting actual online media use during a large-scale crisis event.

ACKNOWLEDGMENTS

We thank the anonymous reviewers for their insightful critique and the US National Science Foundation for funding this research through grants IIS-0910586 and AGS-1331490.

REFERENCES

1. Blake, E.S., Kimberlain, T.B., Berg, R.J., Cangialosi, J.P., and Beven II, J.L. *Tropical Cyclone Report - Hurricane Sandy*. National Hurricane Center, 2013.
2. Crowe, A. The Elephant in the JIC: The Fundamental Flaw of Emergency Public Information within the NIMS Framework. *Journal of Homeland Security and Emergency Management* 7, 1 (2010).
3. Deneff, S., Bayerl, P.S., and Kaptein, N. Social Media and the Police-Tweeting Practices of British Police Forces during the August 2011 Riots. *Proceedings of CHI 2013*, ACM Press (2013), 3471–3480.
4. Fujiwhara, S. On the Growth and Decay of Vortical Systems. *Quarterly Journal of the Royal Meteorological Society* 49, 206 (1923), 75–104.
5. Gibbs, L.I. and Holloway, C.F. *NYC Hurricane Sandy After Action: Report and Recommendations to Mayor Michael R. Bloomberg*. New York City, 2013.
6. Hagar, C. and Haythornthwaite, C. Crisis, Farming & Community. *The Journal of Community Informatics* 1, 3 (2005), 41–52.
7. Hjorth, L. and Kim, K.-H.Y. Good Grief: The Role of Social Mobile Media in the 3.11 Earthquake Disaster in Japan. *Digital Creativity* 22, 3 (2011), 187–199.
8. Hughes, A.L. and Palen, L. The Evolving Role of the Public Information Officer: An Examination of Social Media in Emergency Management. *Journal of Homeland Security and Emergency Management* 9, 1 (2012).
9. Hughes, A.L. and Palen, L. Social Media in Emergency Management: Academic Perspective. In J.E. Trainor and T. Subbio, eds., *Issues in Disaster Science and Management: A Critical Dialogue between Scientists and Emergency Managers*. FEMA in Higher Education Program, 2014.
10. Kendra, J.M. and Wachtendorf, T. Creativity in Emergency Response After The World Trade Center Attack. In *Beyond September 11th: An Account of Post-Disaster Research*. Institute of Behavioral Science, Natural Hazards Center, University of Colorado, 2003, 121–146.
11. Khorram, Y. As Sandy Pounded NYC, Fire Department Worker was a Twitter Lifeline. *CNN*, 2012.
12. Latonero, M. and Shklovski, I. Emergency Management, Twitter, and Social Media Evangelism. *International Journal of Information Systems for Crisis Response and Management* 3, 4 (2011), 1–16.
13. Mark, G., Bagdouri, M., Palen, L., Martin, J., Al-Ani, B., and Anderson, K. Blogs as a Collective War Diary. *Proceedings of CSCW 2012*, ACM Press (2012), 37–46.
14. Mendonca, D., Beroggi, G., and Wallace, W.A. Decision Support for Improvisation during Emergency Response Operations. *International Journal of Emergency Management* 1, (2001), 30–38.
15. National Climatic Data Center. *Billion-Dollar Weather/Climate Disasters*. National Oceanic and Atmospheric Administration, 2013.
16. Palen, L. and Liu, S.B. Citizen Communications in Crisis: Anticipating a Future of ICT-supported Public Participation. *Proceedings of CHI 2007*, ACM Press (2007), 727–736.
17. Palen, L., Vieweg, S., Liu, S.B., and Hughes, A.L. Crisis in a Networked World. *Social Science Computing Review* 27, 4 (2009), 467–480.
18. Qu, Y., Wu, P.F., and Wang, X. Online Community Response to Major Disaster: A Study of Tianya Forum in the 2008 Sichuan Earthquake. *Proceedings of HICSS 2009*, IEEE Computer Society (2009), 1–11.
19. St. Denis, L.A., Hughes, A.L., and Palen, L. Trial by Fire: The Deployment of Trusted Digital Volunteers in the 2011 Shadow Lake Fire. *Proceedings of ISCRAM 2012*, (2012).
20. Starbird, K., Palen, L., Hughes, A.L., and Vieweg, S. Chatter on the Red: What Hazards Threat Reveals About the Social Life of Microblogged Information. *Proceedings of CSCW 2010*, ACM (2010), 241–250.
21. Suchman, L. *Plans and Situated Actions: The Problem of Human-Machine Communication*. Cambridge University Press, New York, NY, 1987.
22. Sutton, J.N., Spiro, E., Butts, C., Fitzhugh, S., Johnson, B., and Greczek, M. Tweeting the Spill: Online Informal Communications, Social Networks, and Conversational Microstructures during the Deepwater Horizon Oilspill. *International Journal of Information Systems for Crisis Response and Management* 5, 1 (2013), 58–76.
23. US Census Bureau, Population Division. *Table 1. Annual Estimates of the Resident Population for Counties of New York: April 1, 2010 to July 1, 2011*. 2012.
24. Wenger, D., Quarantelli, E.L., and Dynes, R.R. *Disaster Analysis: Police and Fire Departments*. The Disaster Research Center, University of Delaware, Newark, DE, 1989.
25. Yonetani, M., Holladay, S., Ginnetti, J., et al. *Global Estimates 2012: People Displaced by Disasters*. Internal Displacement Monitoring Centre & Norwegian Refugee Council, 2013.
26. Zook, M., Graham, M., Shelton, T., and Gorman, S. Volunteered Geographic Information and Crowdsourcing Disaster Relief: A Case Study of the Haitian Earthquake. *World Medical & Health Policy* 2, 2 (2010), 7.