

# When Official Systems Overload: A Framework for Finding Social Media Calls for Help during Evacuations

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## ABSTRACT

During large-scale disasters it is not uncommon for Public Safety Answering Points (e.g., 9-1-1) to encounter service disruptions or become overloaded due to call volume. As observed in the two past United States hurricane seasons, citizens are increasingly turning to social media whether as a consequence of their inability to reach 9-1-1, or as a preferential means of communications. Relying on past research that has examined social media use in disasters, combined with the practical knowledge of the first-hand disaster response experiences, this paper develops a knowledge-driven framework containing parameters useful in identifying patterns of shared information on social media when citizens need help. This effort explores the feasibility of determining differences, similarities, common themes, and time-specific discoveries of social media calls for help associated with hurricane evacuations. At a future date, validation of this framework will be demonstrated using datasets from multiple disasters. The results will lead to recommendations on how the framework can be modified to make it applicable as a generic disaster-type characterization tool.

## Keywords

Disasters, social media, hurricanes, data, framework, emergency response

## INTRODUCTION

During the 2017 hurricane season, the United States experienced three major hurricanes of Category 4 or greater in less than two months. In August 2018, the Federal Communications Commission published a report on the 2017 Atlantic hurricane season and its impact on communications (Federal Communications Commission 2018). The report documented a disruption of service at 41 Public Safety Answering Points (PSAP) in six states and territories as a result of the three hurricanes. Examples of PSAP infrastructure disruptions included: completely out of service; unable to receive incoming calls; no location identifiers available on received calls; unable to re-route calls; and forced to re-route calls to administrative lines or another PSAP. When a primary means of reaching emergency response organizations fails, citizens resort to using social media as an alternative way to try to reach those organizations (Hughes et al. 2014), as well as publicly posting a message requesting help (Rhodan 2017). However, there are several problems in efficiently collecting these requests by emergency response organizations. For instance, in flooding situations—like those resulting from recent hurricanes in the U.S.—the challenge is that as citizens turn to social media to request evacuation help, official emergency response organizations have limited knowledge or experience of information processing in this new media environment (Hiltz et al. 2014; Hughes and Palen 2012; Stephens, Robertson, et al. 2018), especially for filtering this big crisis data to extract relevant, serviceable calls for help (Castillo 2016; Purohit et al. 2018). Furthermore, the public believes official agencies are monitoring social media (American Red Cross 2011), but that is often not the case as most agencies lack the available resources to dedicate to performing this emerging function while simultaneously fulfilling their other responsibilities (Peterson 2015).

In this paper, we use past research on social media use in disasters combined with first-hand emergency response experiences, to develop a framework useful in identifying patterns for the social media posts when citizens issue calls for help. We identify the importance and need for incorporating practitioner experience, knowledge, and feedback into computational methods for information filtering. We also discuss how future research can validate our framework, initially using existing data from past hurricanes, and then extending into other forms of disasters where evacuations are needed. Our goal is to systematize this chaotic process to help emergency response officials make sense of near-real-time data and supplement boots-on-the-ground evacuation efforts.

The rest of the paper is organized as follows. We first describe prior work on social media use in disasters, especially regarding calls for help, and review existing frameworks for processing social media. We then propose our framework for identifying and studying evacuation-related calls for help.

## **SOCIAL MEDIA USE IN DISASTERS**

In the past two decades, research on social media use in disasters has significantly grown (Palen and Hughes 2018; Reuter et al. 2018). With social media technologies (e.g., Twitter, Facebook, Reddit, Snapchat, and Nextdoor), and the prominent use of mobile devices, people have many options for receiving information and even participating in disaster-related conversations (Hughes et al. 2008; Murthy and Longwell 2013; Palen and Liu 2007). Citizens are no longer reliant on official emergency information sources to disseminate urgent information because individuals can function as citizen journalists (Sutton et al. 2008). Meanwhile, emergency response organizations are seeking ways to effectively use social media in their response efforts, which includes searching social media channels for information that could be helpful in the formal response as well as monitoring for misinformation and false rumors that need correction (Denef et al. 2013; Hughes and Palen 2012; Latonero and Shklovski 2011). This type of monitoring can be challenging though, because emergency response organizations often lack the resources (staff and tools), expertise, and managerial support to do the task well (Hughes and Palen 2012; Plotnick and Hiltz 2016). The research presented here hopes to at least partially address some of these challenges by making it easier for emergency responders to find calls for help in the deluge of social media following a disaster event.

### **Social Media Calls for Help**

While we know a considerable amount of literature concerning general uses of social media during disasters (Palen and Anderson 2016), the 2017 Hurricane season experienced a rise in the number of times that average citizens posted messages on social media requesting evacuation and other types of help—a phenomenon we refer to as a *call for help*. This is not necessarily a new practice (Hughes et al. 2014), but the idea of a public call for help is receiving attention from federal agencies like the Department of Defense and FEMA, as well as being seen in the recent research funding from the agencies such as U.S. National Science Foundation. In this paper, we further advance the notion of a *consequential call for help*, defined as a social media post by citizens in a disaster zone resulting from official public safety communication channels such as 9-1-1 in the U.S. becoming overloaded or disrupted as a result of the disaster impact.

By examining social media content, we propose to better understand how citizens interact with the evacuation practices communicated by emergency response organizations. While researchers have shown that private social media can be helpful in understanding what hurricane and flooding-related consequential calls for help look like in terms of images and text (Smith et al. 2018; Stephens et al. 2018), it is important to better understand what can be accomplished using public data from social media platforms like Twitter. Determining meaningful patterns and drilling down to specific disaster-related content, can be challenging using public data (Imran et al. 2014a; Li et al. 2015; O'Neal et al. 2018; Purohit et al. 2014). But once researchers and organizations optimize existing analytical tools for mining such public social data, it will be essential to have a robust methodological framework to systematically improve decision making for response to calls for help.

Getting access to private social media data is difficult, and by using public data, emergency response officials can call upon non-emergency management personnel and citizens to digitally converge and help make sense of social media data. Even though these digital volunteers may have no formal role in the evacuation process or direct contact with emergency response officials, they represent a powerful force that can be ready to serve in times of crisis (Hughes and Tapia 2015; Purohit et al. 2016; Starbird and Palen 2011).

### **Existing Frameworks and Tools for Near-Real-Time Social Media Analysis**

There has been extensive research on social media analytics in the past decade and consequently, several frameworks and tools exist in the literature (Imran et al. 2015; Li et al. 2017; Poblet et al. 2018).

A systematic framework is required to computationally process big social data streams during disasters. Therefore, recent advancements in the design of real-time social stream analytics systems for disaster informatics applications have shown much promise (e.g., CitizenHelper (Karuna et al. 2017), AIDR (Imran et al. 2014b), Twitris (Sheth et al. 2014), CrisisTracker (Rogstadius et al. 2013), Twitcident (Abel et al. 2012)). The primary foundation of these frameworks is the use of machine learning and data mining, which may sometimes be erroneous in descriptive, predictive, and prescriptive modeling due to the lack of generalization of methods across the types of disaster events, languages, and regions. A gap in the design of such frameworks—one that we seek to fill—is that they do not effectively leverage human knowledge. Such knowledge can provide the context for information processing and can be extremely advantageous for improving the efficiency of near-real-time social media analytics during evacuations. We propose the need for utilizing human-in-the-loop methods for machine learning and data mining approaches such as active learning with concept drifts and the hybrid systems of human-knowledge driven rule-based learners and the conventional data-driven learners. Such human knowledge-driven methods would improve the capturing and processing of rapidly changing nature of the concept of relevant information in the data stream as the disaster evolves.

## DESIGNING A PRACTITIONER KNOWLEDGE-DRIVEN EVACUATION ANALYTICS FRAMEWORK

We begin this framework development by identifying distinguishing features of social media content from both citizens and emergency response organizations. This framework was designed with the assumption emergency response organizations are aware their region could be impacted by the pending hurricane and have the ability to collect and monitor hurricane-related social media data. We propose using the Twitter Search API to access information about evacuation-related tweets. We focus on one social media platform, Twitter, to keep our demonstration of the framework manageable. We hope to expand our framework to include other social media platforms in the future. Although images can be helpful in analytics, and research literature has begun to determine how these classifiers will work (Stephens, Li, et al. 2018), we focus solely on social media text to avoid scope-creep in our proposal. With a goal of using this framework in near-real-time situations, we outline a model consisting of six major stages: 1) **planning**, 2) **collecting** data, 3) **filtering**, 4) detecting **location**, 5) **re-filtering** based on changing disaster dynamics, and 6) sorting data into degrees of **relevance** to assist with emergency response. We begin by describing activities that happen before the disaster strikes.

### Planning

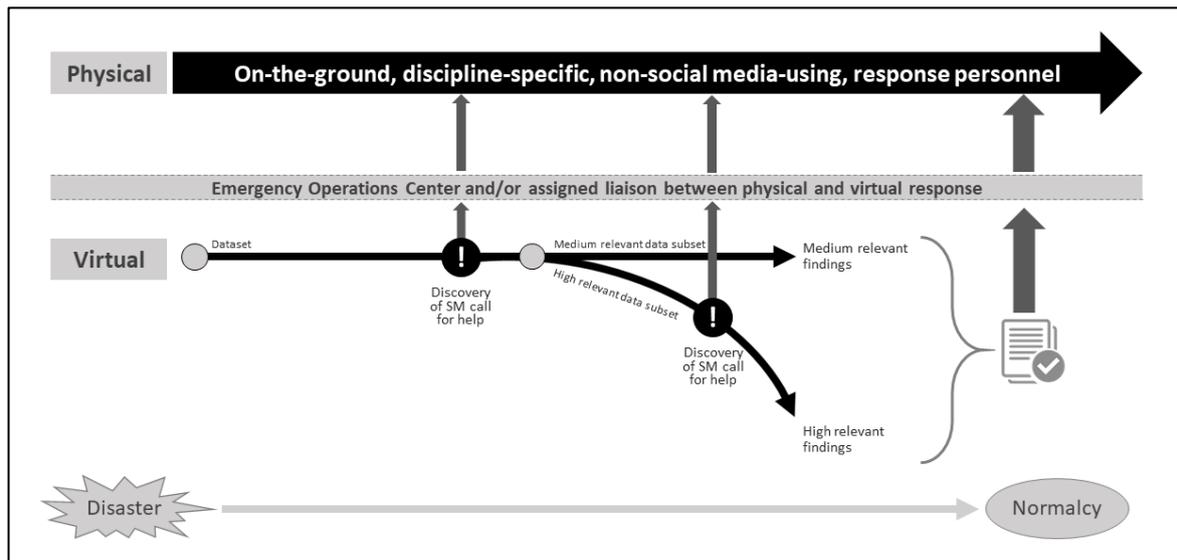
Planning is an integral part of any disaster preparation. There are two key considerations in our framework that must be accomplished during the planning stage: 1) determining meaningful times for data collection and analysis and 2) identifying keywords for filtering.

However, before activity can begin, if research is overseen by an institutional review board (IRB) as part of a data collection and analysis process, getting that oversight process in place before the disaster strikes is important. Several scholars from the National Institute of Environmental Health Sciences Working Group have created helpful documents to assist researcher/practitioner collaborations in working with their IRBs (Packenham et al. 2017). Having conversations concerning how every member of the team will benefit from the intense near-real-time effort is an important part of making these partnerships sustainable.

#### *Determine Meaningful Times for Data Collection and Analysis*

One helpful thing about a disaster that develops over time, as opposed to an immediate threat, is the time people have to make decisions and prepare (Tierney et al. 2001). However, with this time also comes changing conditions—disaster dynamics—and that means emergency responders need to both predetermine and contingency plan for a meaningful time period for near-real-time data collection. This preplanning is important for emergency response personnel who are monitoring social media data because the amount of data will continue, and possibly increase with changing conditions. There needs to be time-points where some members of the team stop monitoring social media and spend time analyzing what they are seeing. This represents a meaningful snapshot that can be fed into the monitoring process to create a dynamic system to identify calls for help.

Figure 1 provides an illustration of how some virtual teams are analyzing social media data and feeding findings back to emergency response personnel. The gray circle represents a time-point during the disaster when data collection ends and analysis begins. The black arrows represent subsets of data created from adjusting the relevancy level of the original dataset. The Emergency Operations Center and/or assigned liaison receive findings from the virtual team and decide whether the information is suitable for communicating to the physical team in the field. This reporting structure is the demarcation between virtual and physical teams and ensures normal operating procedures are not disrupted.



**Figure 1: Example of How Social Media Findings Reach Emergency Responders through a Liaison**

*Identify Keywords*

The second major task to accomplish before a disaster strikes is to determine keywords that have meaning for the respective emergency support function associated with the pending disaster. Table 1 illustrates examples extracted from a list of evacuation-related keyword/search terms our team generated by searching FEMA documentation, referencing past disasters that involved evacuations, and consulting emergency management officials. These keywords have been used to find relevant information in past events. Based on our research, these should form the starting point for a search for evacuation-related social media calls for help. Note that these keywords reflect a combination of transportation-related concepts, as well as descriptive terms helpful when searching public data for relevant indicators of calls for help.

**Table 1. Keyword Sample Proposed for an Evacuation Analytics Framework**

|            |            |             |          |
|------------|------------|-------------|----------|
| alternate  | evacuate   | junction    | relocate |
| blocked    | fuel       | lane        | route    |
| closed     | gas        | mandatory   | shelter  |
| contraflow | highway    | overflow    | traffic  |
| detour     | interstate | parking lot | vehicle  |

We believe generating a large quantity of evacuation-related keywords, communicated either by emergency response organizations or by citizens or a combination of both, will hold a high possibility of discovering calls for help during hurricane evacuations. To strengthen results from this methodological framework, we recommend reviewing evacuation-related social media messages authored by emergency response organizations during past hurricanes to locate additional keywords.

**Data Collection**

After the planning stage, data collection begins. Sources for obtaining social media data during a disaster event include social media platform APIs (such as the Twitter Streaming API) or data aggregation tools. These sources are searched using high-level terms or hashtags (or location bounding boxes for the affected region) that capture a broad spectrum of data, which might be relevant to the event. For example, common terms for a hurricane include the name of the hurricane (e.g., Hurricane Harvey) and the locations affected by the event (e.g., Rockport, Fulton, Houston). As the event unfolds, these terms are often updated. The retrieved data contains a variety of metadata along with each social media message, including the message content, posting time, geolocation

coordinates if available, and the author profile information. The collected data is then stored in a database or a data file for later filtering and analysis.

### Filtering

This step of the framework takes the data collected in the prior step and filters the data using the list of evacuation-related keywords that were determined in the planning stage. To filter the data, a computer program can be used to extract the social media messages containing the keywords. This step produces a subset of data that is more manageable and more likely to be related to an evacuation. A hurricane event usually produces far more information than can be examined manually. Therefore, the filtering step is important for narrowing down evacuation-related information, including calls for help, required to be examined more closely.

### Location Detection

The next step in our framework is to associate a location with each message (when possible). Having a precise location for a call for help is essential provided the goal is to physically rescue the individual(s) or to provide evacuation-related information relevant to their location. But obtaining location information can be challenging when using public social media. A direct way to get location data is through geolocation metadata automatically embedded in the tweet data, however, geolocation data is not required and most messages do not contain it. Location can also be inferred from user profile data, social connections, or the content of the message (Stock 2018). Sometimes location data is manually entered by the social media end user. For example, during the 2017 hurricane season, some people posted their own address publicly, or a friend or family member did this for them (Stephens, Robertson, et al. 2018). For example, messages like this occurred:

*My mother needs help. 3390 ISCRAM Lane. 2 older adults, 1 dog.*

There could be considerable privacy issues with this practice, but it appears that some people do not consider that a barrier when they feel their life is in jeopardy. Two challenges are associated with this process of manually sharing location data: redundancy and closing the loop (Smith et al. 2018). It is quite possible for multiple people to post the same location data either without or with full knowledge that these are redundant posts. Another challenge found in coordinating these types of rescues is that once someone was rescued, there is no easy way to close the loop (Smith et al. 2018). This challenge provides further evidence of the importance of emergency response organizations, or the dedicated resources assisting them, to centralize findings and communicate to responders in the field. Responders in the field are emergency response organizations' ground truth – confirming or delegitimizing social media calls for help. Therefore, in the process of including location data into the decision-making process, people monitoring social media should pay careful attention to redundancy, and look for alternative verifying information suggesting that people have been rescued.

### Re-Filtering

In this step, we re-evaluate the way the data has been analyzed and filtered up to this point, incorporating insights based on changing disaster dynamics and the results of the location detection step. Figure 1 shows how it is not uncommon to have multiple teams analyzing social media, and this re-filtering step is a place in the framework where these teams can inform and shape the social media strategy for all teams. Re-filtering allows different views on the collected data for creating the task-specific filtered sets for different functions of the response stakeholder teams. This is also an opportunity to incorporate practitioner expertise into the filtering and analysis. Unlike most other analytics frameworks for social media in disaster, this framework seeks to leverage human knowledge (especially that of practitioners) and the re-filtering step is an important place where this can happen.

### Message Relevancy

When combining the filtering process with location detection, the next step in our evacuation analytics framework invites people monitoring social media to assign relevancy criteria to each piece of data. Once again, the goal is to simplify the decision making during the chaos of a disaster, so we propose using a simple four-number Likert Scale rating system to help rate the quality of the calls for help data as done in the prior work (e.g., rating the serviceability characteristics of social media requests (Purohit et al., 2018)). The highest quality call for help is assigned a 3 and contains both evacuation-related key words and location information. Next, if the location information is missing, but the key words still indicate the tweet is evacuation related, it is assigned a 2. If there

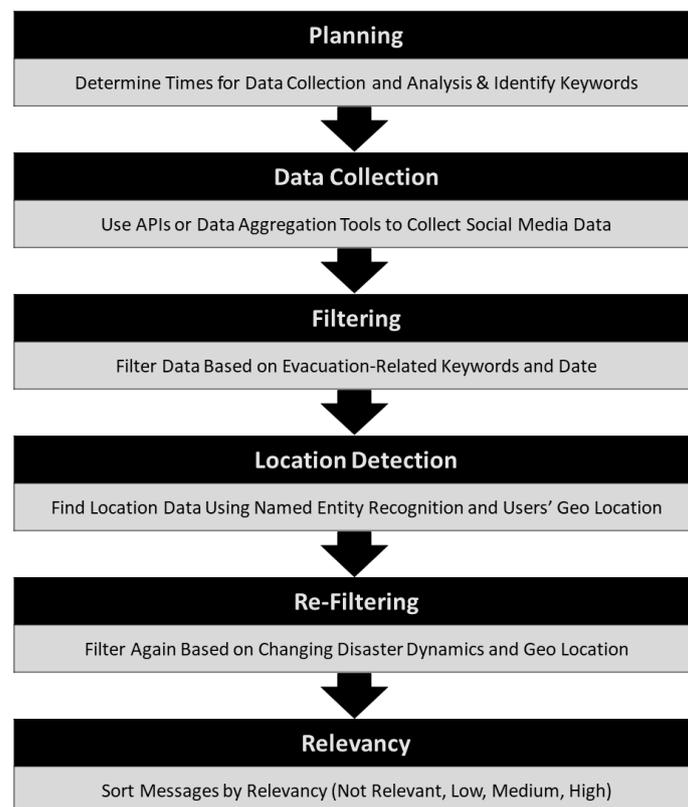
is no location information and the key words are not clearly related to an evacuation need, it is assigned a 1. Finally, for all data that does not seem related to an evacuation, it is assigned a 0. Table 2 explains this rating system succinctly. The results of this step can then be aggregated and reported to the relevant emergency response organization.

**Table 2: Criteria for Rating Filtered Twitter Data**

| Rating | Relevancy                    | Criteria                                   |
|--------|------------------------------|--|
| 3      | [HIGH] More accurate         | Evacuation-related and location identified |
| 2      | [MEDIUM] Moderately accurate | Evacuation-related                         |
| 1      | [LOW] Less accurate          | Evacuation-related uncertainty             |
| 0      | No relevancy                 | No correlation to evacuation               |

**The Framework**

Our proposed framework (described above) identifies and isolates actionable intelligence associated with evacuations. This framework could become a pre-emptive strategy for implementation in future advance notice disasters, such as hurricanes, by practitioners. Figure 2 provides an overview of the steps in our evacuation analytics framework.



**Figure 2: Framework for Extracting Evacuation-Related Social Media Content**

**VALIDATING THE PROPOSED FRAMEWORK**

For validating the framework developed here, we propose using an approach similar to one used by Banujan, Banage, and Paik (2018). To ensure we have captured the most crucial, indispensable keywords that would be advantageous in extracting meaningful data from Twitter, we plan to compare three different social media disaster datasets related to hurricane evacuation. Also, we will perform a comparative analysis between the filtered results by consolidating all three dataset findings. This should surface data that identifies and describes common themes that will shed light on human behavior during hurricane crises. These findings may also aid emergency response organizations to take pre-emptive communication measures in future disasters, during the pre-crisis phase, to

disseminate time-sensitive emergency messaging.

However, the question remaining is whether citizen reports on social media during evacuation periods can be gathered, consolidated, analyzed, categorized, and verified for accuracy in time to be helpful during the same evacuation period. Conducting a comparative study as suggested in this paper should aid in answering this question. Specifically, applying the integrative methodology to the datasets should confirm whether or not this is plausible.

## DISCUSSION

In this research, we propose a systematic framework that can be used to streamline a near-real-time public social media strategy to identify calls for help. Our review of the literature combined with the knowledge of emergency responders identified the importance of integrating social media planning—i.e., key word identification—into the disaster preplanning processes. Furthermore, by establishing multiple teams of social media monitors and analysts, these groups can more quickly identify calls for help, determine location data, rate the overall data, and share the prioritized data with responders in the field. This framework may seem overly simplistic. However, considering that social media has often been the afterthought of an emergency response, this practitioner knowledge-driven analytics framework can help systematize the inclusion of this important publicly communicated data within emergency response organizations' efforts in responding to a disaster.

## Future Directions & Conclusion

The next step for this research, and one in which we are currently engaged, is to validate our framework using multiple hurricane data sets. Once this step is complete, we can see if with different keywords, the framework could be successfully applied to other disaster types. It will be important to ascertain if the framework can be applied to both advance-notice and no-notice disasters. It is also prudent that non-evacuation related social media calls for help are also captured, categorized, and studied to influence future mitigation efforts in the respective emergency support function areas.

We hope findings from studying multiple datasets—the keywords, differences, and similarities—will better position practitioners in future hurricane situations, as well as in other types of disasters. Testing and implementing this proposed framework for discovering actionable social media data pertaining to disasters could aid agency policy makers in adopting and promoting more integrative approaches to rescuing people. Results may also provide practitioners, especially those advocating to include social media, further evidence concerning how to retrieve, validate, and understand near-real-time social media data. This could assist in decision making as well as strengthen confidence in social media. It will take considerable research efforts, but these results may be the catalyst for addressing this need (Peterson et al. 2018). Finally, results may shed new light on this underexplored, critical area of the response phase of emergency management. These efforts have the potential to further enhance the value of preparing, responding, and recovering from emergencies by embedding social media within various constructs/organizational structures.

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