Social Media Analysis in Crisis Situations: Can Social Media be a Reliable Information Source for Emergency Management Services?

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Abstract

Learning and understanding what happened before, during, and after a crisis is extremely important for the improvement of the response process. For this purpose, social media has become an important communication medium used by both the affected persons and the emergency management services (EMSs). However, in different crises, different information may be needed, and the information shared in social media varies in its usefulness: It could be highly critical or completely irrelevant to the rescue operation. Supplying the best possible up-to-date information is crucial to the EMS, whose actions based on that information may save lives and resources. This paper studies a particular use case of extreme weather in Norway and identifies the information needs, the problem faced by EMSs, and how they use social media. It, further, pinpoints what different social media analysis platforms can provide in this type of crisis. The results of the research are criteria that social media analysis should follow to address EMSs' concerns. The output of this work can be used to more precisely describe social media communication for crises and to design more efficient platforms for information retrieval from social media.
Keywords: Social media, Crisis management, Emergency management services.

1. Introduction

Social media has become the de facto medium for public crisis communication [38]. It plays a pivotal role in most crises today, from obtaining life signs from people affected to communicating with EMSs [11]. Three types of information sharing on social media during a crisis can be distinguished. First, from EMS to the public: EMSs relay situation updates,

evacuation orders, possible dangers... to the public. Second, from the public to public: the public uses social media to maintain contact with relatives, friends and loved ones, and to show support for the community. Finally, from the public to the EMS: The public uses social media to report problems, needs, calls for help, and provide information throughout the crisis. The first two information sharing types are now well established with training given to EMSs on how to effectively communicate information to the public [8][7]. Many social media platforms are also providing ways for people in the affected area to report their safety status. The third type, on the other hand, is still facing many challenges. Although the information shared by the public can enhance the situational awareness of the EMS, many EMSs are still skeptical about using that information.

A priori, the EMSs' skepticism might be due to the nature of the massages posted on social media during a crisis: These messages tend to vary in their usefulness highly: The message can be off-topic, personal, or informative. Much of the retrospective research on Twitter messages posted during events show that those messages can identify the problems appearing during the relief effort. Finding this useful information can accelerate disaster response. However, the task is not easy due to, among other things, information overload. In an analysis performed on tweets related to the 2015 Nepal earthquake, discovered that even though relevant topics are discussed, the information present in the discussions is often irrelevant [24]. As an example, monetary support is one of the most discussed topics, but the majority of the messages are appealing for donations from ordinary people outside the affected areas and not actual financial needs which are more relevant to the EMSs.

In addition, the way rumors and misinformation are spread on social media makes it an untrustworthy source of information [31]. The social media analysis platforms can also be to blame for the EMSs' skepticism: Most of the social media analysis platforms during a crisis follow a data-driven approach that analyzes the data first by finding ways to extract as much information related to the crisis as possible [31][32]. Such an approach may result in information obtained during the analysis that is not useful to the EMS, as opposed to an approach that inspects the data in ways that make it pertinent to the meaningful questions for the EMS. Many of previously listed reason are founded. However, do they make social media irrelevant as information sources for EMSs? In this paper, we contribute to bridging the gap that exists in information sharing from the public the EMS in social media.

We will focus on an extreme weather use case in Norway. Around this use case, we conducted an interview with governmental EMSs that include the police, firefighters, municipality, and red cross. The aim of the interviews was to learn about the standard operating procedure in an extreme weather crisis, how the EMSs share their information and establish situational awareness, and what role social media plays in the emergency response process. Further, we present an overview of the information social media can provide and the state-of-the-art social media analysis platforms. By studying the data availability and needs from both the EMSs' side and the social media side, we try to identify the common denominator between the two. This paper contributes to addressing the question of how social media analysis platforms should be designed to effectively support EMSs.

This paper is organized as follows. Section 2 presents our interview methodology and outcome. Section 3 illustrates the diverse types of information social media can provide during a crisis. Section 4 gives an overview of the state-of-the-art social media analysis platforms in crisis situations. Section 5 discusses the lessons learned from our study and present the primary outcomes of the paper. Finally, Section 6 concludes and provides pointers to future work.

2. Crisis response procedures and information needed

Extreme weather is the most damaging and frequent type of crisis in Norway (Norway experiences on average 3 per year). It is characterized by an unusual and unexpected rainfall, snowfall, heat or cold waves. When it occurs, extreme weather may damage the infrastructure

including roads, leaving towns cut off from the rest of the country, the electricity network (for example, during the storm Hilda in 2013, 35000 homes were out of electricity), and, most importantly, it may lead to human injuries and death. The EMSs that are highly involved in this type of crisis are the police, firefighters, municipalities and the Norwegian red cross. To find out which information these EMSs need, we conducted a two-hour semi-structured personal interview with representatives from four prominent local authorities on May 23, 2017: the chief of staff at Agder police district, the crisis preparedness leader at Kristiansand municipality, head of a unit at the Grimstad fire brigade, and a volunteer in Grimstad Red Cross. By using the extreme weather use case, we managed to put the interviewees in a familiar situation in which they have a lot of experience to get the most out of the interviews. The interview was oriented to discover the current crisis response procedure, the information needed during this process, the practice in information gathering, and the gaps of such practice. We brought up social media during the interview to discover how the EMSs currently use it their opinions about its potential.

2.1. Methodology

Since we are concerned with the public-to-EMS information sharing through social media, the interview aims first to understand the current crisis response and information gathering procedure and identify the problems facing it. Further, we try to learn the extent to which social media is currently used and what they think about its potential use in crisis situations. Therefore, the questions we asked were oriented to achieve those previously cited goals. The questions were:

- How do you proceed during a crisis?
- Which kind of information do you try to collect?
- How do you obtain this information?
- What are the biggest problems you face in this information collection process?
- Do you use social media as an information source?
- Would you be interested in analyzing social media?

For each of the above question, we asked a series of follow-up questions depending on the participant's response. The analysis of the interviews was done qualitatively following the Mayring approach [15]. When analyzing the interview data, we looked at the opinion held by the EMSs on two critical question for this paper.

The first question is: How do they assess the current information gathering process during a crisis? For this question, we distinguish three categories of opinions: high, middle, or low, confidence in the process. Then, we classified the answers of each participant to one of the previously listed categories. The second question is: What do they think about the use of social media in crisis situations? Here, we separate between enthusiastic, halfhearted and skeptical views. We further classified the interview data into one of these categories based on the opinion each participant holds.

2.2. Findings

In Norway, during a crisis, police forces oversee the situation and responsible for the response. The police operation center should have the overall picture of the crisis and act accordingly. In the case of extreme weather, the most valuable information EMSs need to know are:

- Which are the affected areas and people?
- What are the areas in danger that need evacuation?
- How fast is the water rising?
- Who has already been evacuated and who still needs to be evacuated?

- Do the evacuated people have what they need?
- Do individuals in a threatening situation know they need to evacuate?

Description of the current information gathering process

The information needed during an extreme weather crisis is diverse and sometimes very hard to get promptly. To get that information, EMSs receive phone calls updated from all the emergency call center, regional authorities, and other EMSs for updates about the situation: "In current practice, we get our information through reports from emergency call centers. Besides, we gather information by visiting some news, weather and media websites. But apart from that, we do not collect information from other sources. The rest is information from the staff we send to the event location," the police representative said. The police officer agrees that there are other techniques to gather information they can use to improve their assessment process.

"During search and rescue operations, the more useful information we have, the better the operations. It is very crucial to gather as much information as possible as quickly as possible," asserted the Red Cross volunteer. The amount of information available early in the process that helps direct the crews to the right spot, such as, for example, which places have been searched for the last two hours, is crucial to the rescue operation. As it is now, the red cross representative thinks that gathering the necessary information is a process that takes time: there is a lot of information available in sources such as social media and news reports that can be more efficiently collected using simple internet search that is not collected because the EMSs lack the technological tools.

The lack of information during a crisis can lead to unexpected incidents for the EMSs. As an example, the Kristiansand municipality representative shared with us his insight on a flood that happened in Kvinsdal, Norway in 2014. The region experienced 130mm of rainfall in the mountains over one night. To put this in perspective, 44.2mm is a normal rainfall in Norway. The water took 12 to 18 hours to reach the town. When it did, the city bridge was damaged, boathouses destroyed, and the cultural center submerged. The damages could have been avoided with more coordination between the municipality, the firefighters and the police. Due to this lack of coordination, no one had an overall picture of the situation and could assess the extent of the crisis. This lack of a full picture and understanding of the situation caused the authorities in place to allocate fewer resources than necessary. The civil protection, for example, understood the extent of the water flood only when a civilian called to get help pumping water out of his basement. The firefighters went from house to house trying to help the inhabitants, but they had no idea about the overall extent of the flood. "Having the right picture of the situation allows the persons sitting at the top to make the correct decision based on the right reasons," the municipality representative asserted. He thinks that the main reason behind the shortcoming in getting the overall picture is the lack of coordination and proactive information sharing between different EMSs.

Potential use of social media in crisis situations

When we asked the interviewees about their experience with social media so far, they all agreed that they only use social media to communicate updates to the public and monitor social activities of other EMSs. However, when asked if it can solve some of the information needs problems, their sentiments were mixed: The police representative was enthusiastic about the idea. For him, it is important to include technology in crisis management work, especially information from different data sources including social media. This information should enter the control room, and the decision-makers should have access to those data. The Red Cross representative was less enthusiastic, stating: "If we can use social media or other information sources to identify where our presence is needed most instead of sending persons on the ground, that would help save us a lot of resources. But I cannot see how." This quote illustrates one of the gaps that exist between EMSs and social media analysis: Despite the abundance of tool we

describe in Section 4, the EMS officers we interviewed are either unaware of their existence or do not see how these tools can be useful for them.

Finally, the municipality representative was more skeptical of the idea of using social media for information gathering. He did not see how social media can help get a better overall picture of the crisis. Despite the downfall that the current procedure might experience, he does not think that social media is the answer. He stated that “we only use information from different EMSs to get an overall picture. We do not rely on `Mr. Somebody' for the information.” This statement also reflects the trust issues toward the information shared on social media.

3. Information in social media

Data produced and shared in social media like Facebook, and Twitter has proven to be valuable in many different contexts. The previous section reviewed the current information sharing procedure for the EMSs we interviewed and the problems and gaps they present especially in getting a comprehensive picture of the situation. In this section, we examine the various kinds of information that are available and accessible on public social media platforms in specific cases and argue that this information can help solve some of these problems.

3.1. Textual information

Though social media nowadays seem to give more weight to other types of information, purely textual information is still at the heart of most platforms. Textual information is externalized, explicit or codified and accessible with automated techniques [32]. Depending on the language, textual information follows specific grammar rules which allow one to access even free and unstructured text. Dictionary-based analyses allow the selection of relevant texts according to a defined set of keywords or to assess sentiments in social media regarding a particular topic.

During the recent hurricanes Harvey and Irma in the United States and the Caribbean, a lot of textual information was shared in social media. For example, the following Figure 1 depicts information from the social networking site (SNS) Facebook about a person that needs to be evacuated for special treatment due to her diabetes.

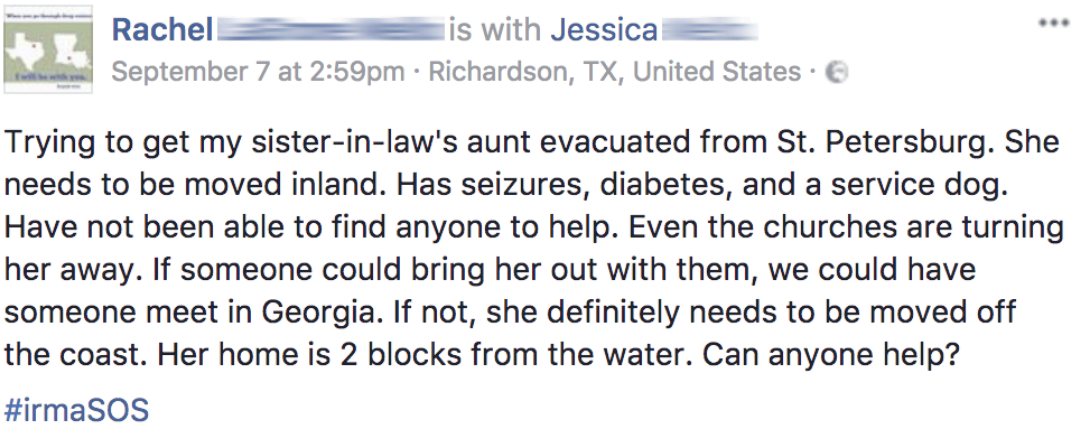

Fig. 1. Facebook post

In Twitter, people also shared information on where to find shelters (Figure 2). This behavior has been observed in other crises, too [35]. This information can be useful for emergency authorities as well, as they might not be aware of all shelters.

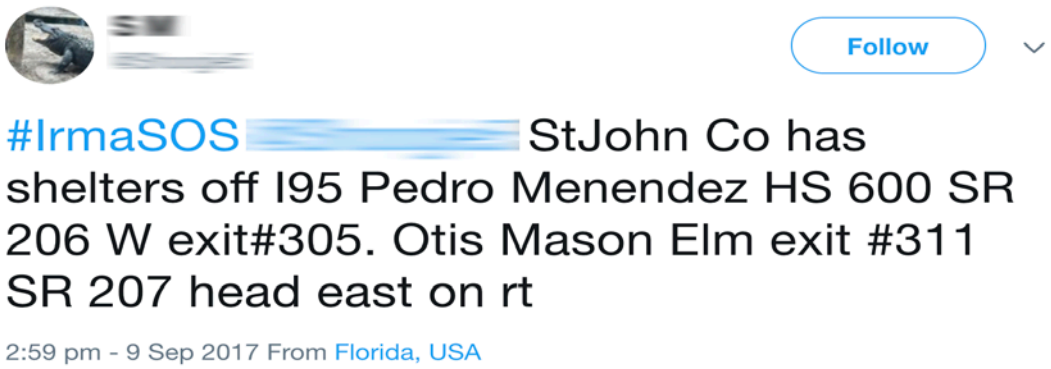

Fig. 2. Twitter post

Often, the textual information is used to cluster the high number of posts into relevant and irrelevant posts or further categories [37]. Textual information is often used in aggregation [16]. Still, the individual text may contain information that can be relevant for the response management, e.g., about the inundation height in a particular area. The challenge for textual information is to define and improve filters and other relevance criteria that limit the number of posts to a manageable number.

3.2. Photos and videos

Most social media platforms are capable of sharing not only text but also pictures and videos. Although the complexity of processing information in pictures or videos is much higher than for texts, they can also inform emergency service agencies better. For example, Fohringer et al. [5] use photos taken by eyewitnesses to derive quantitative data about water depth. Photos and videos depict the real situation on-site. In contrast to textual information, multimedia data is more objective and does not require laymen to interpret what s/he observes locally.

Figure 3 shows a photo taken from a small flood in Oslo, Norway, and published on Twitter in August 2016. The picture illustrates to the emergency service agencies: The depth of water at the particular place, a car stuck in the flood, the road in need to be closed, and that people do not seem to be injured.

(Live) videos shared on social media platforms usually contain even more information than photos [20]. Videos can better convey, e.g., weather conditions or crisis dynamics. In the case of floods, videos could be used to measure the flow rate. New services like Periscope, which offers an easy-to-use live broadcast, are expected to become ``game changers" (p. 8) in the disaster response management because intermediaries can be skipped and hence, transfer time reduced [4].

Fig. 3. Photo depicting a flood in Oslo from Twitter

3.3. Spatial information

Most social media platforms provide location data for shared information, especially if mobile devices with built-in location sensors (e.g., GPS) are used. Spatial information can be used to filter for posts sent from a particular area [37] or to visualize shared information, e.g., with a map [6]. Often, geospatial information is not enabled by default, making the precise location of information impossible. In such cases, textual information mentioning the city or street have to serve as a proxy.

3.4. Response information

Comments, answers or commented retweets can contain information that complements the original information. In Figure 4, the person first added @mentions to attract the attention of authorities. Later, she wrote the full address.

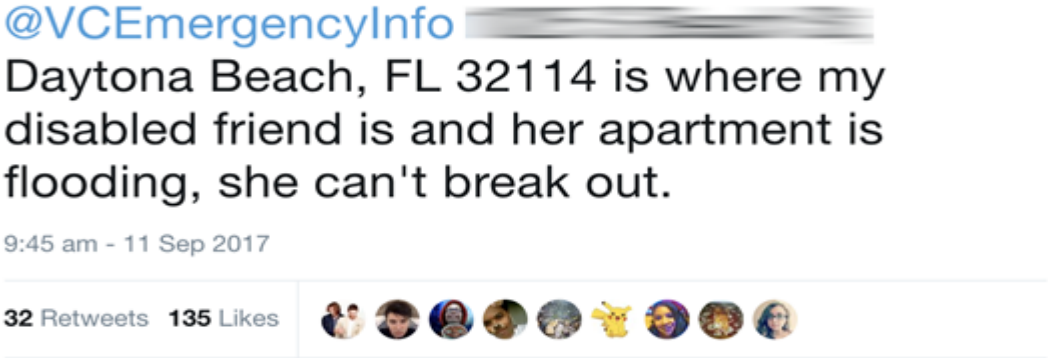

Fig. 4. Added details in Twitter reaction

Eventually, the reply feature was also used to report the successful rescue. Hence, response information is a valuable information source as it contains information about the actuality or allows a better assessment of the severity of the reported issue (see also next section).

3.5. Quantitative information

Although some of the information mentioned above is also quantitative, we specifically want to point to other numbers available. Reactions to original posts, e.g., expressed as a Like on Facebook, or a Retweet on Twitter, can contain information about the urgency of the textual or other information. Hence, quantitative information could help to prioritize open issues reported through social media [11]. The pure number of comments or answers further indicates relevance. Lastly, before a crisis happens, emergency service agencies can use available quantitative data to assess and improve their potential reach that is also based on followers and like numbers of official accounts.

4. State of the art in social media use in crisis situations

Social media can provide near-real-time information for the emergency responders to make effective decisions throughout various stages of the disaster management process [10][33]. It also facilitates connectedness during the emergency and provides relevant and timely information from both official and non-official sources [29]. This information act as an artifact in the online environment [36]. After examining the different kind of information available in social media in some specific cases, this section takes a more global view on the platforms available for social media analysis and how it is used around the world.

4.1. Use of social media in crisis

Social media was used as a participatory media during Hurricane Katrina (2005); one of the first natural disasters where social media use was noted [23]. People used online platforms to help affected people by donating clothes, toys, etc., and social media helped emergency responders to coordinate [30]. Palen and Liu [23] noted that social media also played a significant role in finding the missing people in Hurricane Katrina. These cases marked the start of social media uses in crisis situations by EMSs; after that, social media data, or more precisely, Twitter data, has been heavily utilized in the management of almost every kind of disaster [3], for example the 2009 Red River flood in the US [34], the 2010 Haiti earthquake [27], the 2011 Japan tsunami [1], the 2015 Nepal earthquake [24] etc.

During the Haiti earthquake in 2010, digital volunteers used Twitter data to map the affected areas using Ushahidi. This crisis map became an invaluable resource for relief workers in the field [27]. During the 2015 Nepal earthquake, the Nepal police used social media as one of the main communication channels [28]. Kathmandu Living Lab prepared a Nepal quake map based on social media data [13]. The open nature of social media data helps the responders to operate from the ground. Social media are now gaining attention among those dealing with extreme weather disasters [19].

4.2. Social media analysis platforms

It is always challenging to analyze social media data because of the diverse sources and unstructured nature of the data. Facebook, Twitter, and other social media platforms do not provide similar kinds of data, thus the need for social media analytics tools to analyze this data. There are few platforms available used by the volunteers to analyze this unstructured data of social media during any crisis. The following list mentions a few standard tools.

- Artificial Intelligence for Disaster Response (AIDR)
- Tweak-the-Tweet

- Ushahidi
- TweetTracker
- TweetCred

The mentioned tools work for Twitter data sources or a combination of other social media platforms. Artificial Intelligence for Disaster Response (AIDR) uses machine learning to identify crisis-specific Twitter data automatically. By using a small of labeled tweets, AIDR allows one to detect the categories of tweets [12]. Through the identification of the category of tweets, it helps the responder to react to particular issues rather than the crisis as a whole.

Researchers at the University of Colorado developed a crowdsourcing platform called Tweak-the-Tweet. It focuses on specific hashtags to make the data structured [14]. After that, a parsing algorithm can be used to extract the information. One of the benefits of this system is that it can work with the existing social media infrastructures [27].

Ushahidi is a crowdsourcing platform first developed to map the reports of Kenyan post-election violence in 2008. Later it was widely used during the Haiti earthquake and Hurricane Sandy. This system is not only used to collect Twitter data. It can also be used to gather data from RSS feeds, email and SMS [26]. This variation makes this system more attractive.

To collect data from Facebook, Twitter, YouTube, etc. with a combination of keywords, location, and user information, TweetTracker was developed. It can easily map the geotagged post. There is a particular module in TweetTracker to facilitate disaster relief [18].

It is essential to get credible information during a crisis to assess the situation accurately. Due to the dynamic nature of social media, fake news can spread quickly and create a mess on the ground [21]. TweetCred was developed to find credible information shared by Twitter users in real time. It provides a credibility rating of a post, and a supervised automated ranking algorithm determined the credibility of that post [9].

5. Discussion and lesson learned

Social media is a platform with a significant potential to be used for public-to-EMS information sharing. We showed in the previous section that the information available in social media during a crisis can address EMSs' needs and help them establish a better situational awareness, and complements the current information gathering procedures to get a complete picture of the crisis. However, social media is still not considered a source of information for governmental EMSs in Norway as well as in many other countries around the world. It is understandable that EMSs question the value of social media for crisis response because of the gap still present in social media analysis and research. In this section, we will pinpoint these gaps based on the outcome of previous sections.

One of the main reasons behind the skepticism behind using social media as an information source by EMSs is the lack of confidence in the information present in the platform: As mentioned by our interviewees, they do not trust “Mr. Somebody” to deliver accurate situation update and needs. This concern is founded on the amount of rumor and disinformation spread in social media during a crisis [31], which leads us to the first question a social media analysis platform needs to answer: can it establish a trusted network of people to get the information from? A lot of research has been carried on developing an automated trust model for social media networks based on user behavior and interaction with other [25] [17]. However, none of these methods are integrated into the crisis-related social media platforms described in section 4.

Social media content varies in quality from excellent to spam and abuse. Once a trusted network is established, we need to ask how we can ensure that only high-quality messages shared by the network are treated by the platform? By quality of the message, we mean one that is clear, readable, and concise. Information quality assurance models to identify high-quality

information are another evolving topic of research in social media [2]. Nevertheless, their integration in social media analysis platform for crisis response is still unsatisfactory.

Many data scientists are relatively new to the field of social media in crisis research. They are knowledgeable about the management and analysis of large-volume data but lack the understanding of the EMSs' needs. Data scientists tend to think that large volumes of social media data alone will reveal patterns of behavior during a crisis. Moreover, the growth of artificial intelligence and machine learning during the last few years has led to the emergence of many artificial intelligence-based analysis tools [12][37][11]. These tools analyze the data first by extracting as much information about as many topics related to the crisis as possible. When the focus is on the data, and its volume, rigor in data collection becomes an afterthought. In contrast, social media data must be analyzed in ways that provide relevant answers to the question asked by the EMS, which usually triggers new data collection steps and questions. For a social media analysis platform to be efficient in a crisis situation, it needs to focus on answering EMSs' questions and needs. To summarize, the list of question that social media analysis platform need to answer to be an efficient tool for EMS during a crisis situation are:

- Can social media analysis platforms establish a trusted network of people to get the information from?
- Can social media analysis platforms ensure that only high-quality messages shared by the network are treated by the platform?
- Can social media analysis platforms analyses social media data in ways that provide relevant answers to the question asked by the EMS?

Table 1. Complice of socail media analysis platfoms to the critera deduced from this research

Socail media analysis platform	Trusted network	Quality of infomation ensurance	Important EMSs question answering
AIDR	×	×	×
Tweak-the-Tweet	×	×	×
Ushahidi	✓	×	×
TweetTracker	×	×	×
TweetCred	×	✓	×

Table 1 shows how the current social media analysis platform discussed in section 4.2 comply to the criteria discussed in this section. Many of these approaches are just data driven classification of social media message. The table shows the gap that still exists between what the social media analysis platform ca provide and what the EMSs require.

6. Conclusion

The information available on social media during a crisis, from textual information to information in images and videos, can improve the current information gathering procedures of the EMSs, help them get a better overview of the situation, assess the crisis response effort as well as discover what the people in the affect areas need. Despite this information, EMSs in Norway are still reluctant to use it as an information source. In this paper, we investigated the reasons behind this reluctance via interviews with four major EMSs in Norway. As a result of this research, we were able to assess what the social media analysis platforms currently lack and should provide to address the concerns of the EMSs. The criteria are a trusted network, information quality assurance, and answering the meaningful question for the EMSs.

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