Accepted manuscript

Ecosystem of Social Media Listening Practices for Crisis Management

Lucia Castro Herrera[1] [0000-0002-6254-8720], Tim A. Majchrzak[1] [0000-0003-2581-9285], and Devinder Thapa[1][0000-0003-1111-7194]

[1] University of Agder, Kristiansand, Norway
{lucia.c.herrera,timam,devinder.thapa}@uia.no

Abstract. The benefits of using social media data as a source of information are recognized by both practice and research in crisis management. However, the existing understanding on the matter is fragmented, it oscillates between techno-determinisms and socio-determinisms, which does not provide a holistic picture. In this paper we argue that to better adapt social media data use practices, an ecosystem perspective is needed. In doing so, we conducted a systematic literature review and identified the various entities and their interrelationships that configure the practices of social media listening for crisis management. Then, we summarize our findings by proposing a conceptual ecosystem of practice. Finally, we suggest its implications for future research and practice.

Keywords: Social media listening, practice, ecosystem, crisis management.

1 Introduction

Harnessing social media data has rapidly become a favored non-authoritative source of information in different fields. Businesses and academics increasingly adopt such data to perform their analysis and operations. The benefits of enabling social media listening, also known as *monitoring*, *intelligence*, *analytics*, *citizen-generated content*, and *surveillance* (SoMLIS), in crisis management are increasingly recognized especially in instances where access to other sources of information is scarce or costly [1]. SoMLIS, in essence, refers to the extraction, analysis, and reporting of insights from social media. This task is carried on with the help of technology solutions in the form of software, apps, or websites that offer social media listening and analytics capabilities. In SoMLIS practices, social, technological, organizational, and contextual features with unclear boundaries work together to fulfill information objectives that influence decision-making [2]. Hence, it is important to understand the ecosystem where SoMLIS practices are enacted to comprehend the emergence of information that contributes to decision making [3,4].

Thus, by conducting a systematic literature review, we propose the *SoMLIS ecosystem in crisis management*. In doing so, we found that SoMLIS practices are inherently different and context dependent. However, the findings illustrate commonalities and overarching themes that can be generalized into a conceptual model. The model depicts the structure of the SoMLIS ecosystem that guides practice

configurations. The rest of the article is structured as follows: Section II describes the literature review process. Section III presents the findings, and Section IV presents a discussion and future research directions.

2   Methodology

This systematic literature review follows the general structuring approach from Okoli and Schabram [5]. After a rigorous process of selection of the literature (Fig 1), we identified 109 articles for analysis. The scope included empirical studies written in English, with no publication timeframe, and with a focus on social media use as a source of information in crisis management.

We leveraged Boolean operator searches to retrieve the literature. The process started with a test-search on Google Scholar and other academic databases with the terms "social media listening" and "crisis", resulting in mostly irrelevant articles from diverse disciplines. Thus, we refined the search stream by integrating associated terms of SoMLIS, crises, and practice. We consulted five academic databases covering a wide range of study areas: AIS eLIbrary, Scopus, Web of Science, IEEE Xplore, and ProQuest. Then, automated filtering was applied to include relevant fields of study and reduce the volume of the literature. However, the breadth of results was still unmanageable. Subsequent manual steps were completed to select, screen, and analyze the literature. First, we performed title and abstract screenings and a preliminary content analyses following an inductive approach: abstracts were read and classified by field, methodology of analysis, subject, and practice type [5]. As a result, the following main categories emerged to classify the literature: *social media environment, social media use in practice and organizational configurations, other sources of information, and visualization of results*. These became the basis for further formulations of concepts, themes, and classifications. Our results and propositions are summarized and discussed in the following sections.
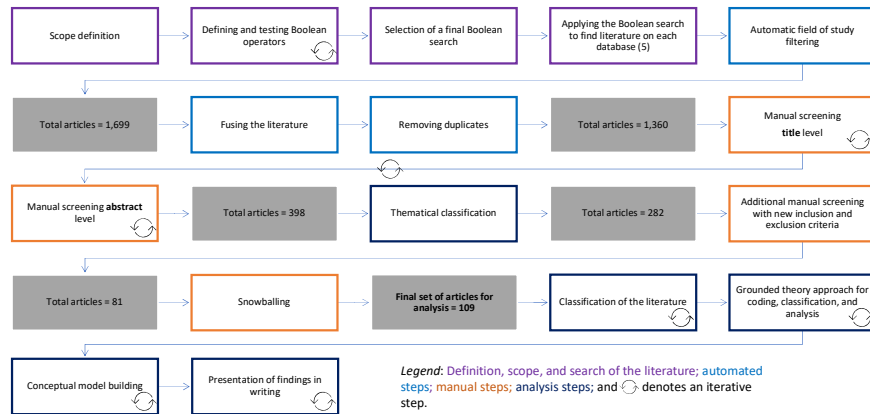

Fig. 1. The systematic literature review process

3 Findings: The entities of SoMLIS

This section generalizes and describes *entities that participate in SoMLIS practices*.

3.1 Context

Context is the encompassing boundary that defines and re-defines the uniqueness of each enactment of SoMLIS practices and subsequent actions in crisis management. There are different views of context that can be classified but not limited to:

- *Crisis related*: While most of the analyzed literature focuses on social media use during the response and short-term mitigation of a disaster, SoMLIS contributes to the entire cycle, from preparedness and eventually risk reduction [6].
- *Location features*: Demographics of impacted area, location, level of disaster risk [7], socio-economical features, connectivity levels (infrastructure, broadband, accessibility and capabilities). Intrinsic to the place where crisis and practices are placed as it could be located remotely.
- *Organizational environment and patterns of collaboration*: The organizational, technological, and environmental resources, configurations, and techno-social capabilities situated under the organizational umbrella influence the adoption, design, improvements, and continuous enactments of practice [8], as well as the quality and trust in information extracted from social media [1], and the integrations of systems and collaboration patterns within and across organizations [9,4].

Context is not external to the configurations of the SoMLIS practice, but the opposite, the practice obtains its properties from the deep awareness and intrinsic relationship of such context. This awareness stems from accumulated knowledge of disasters and crisis response [3] or observed from following in the social media conversation [10]. Moreover, an assumption latent in social media research for crisis management is that technology is perceived as a universal solution [8] that calls for a change in rigid command and control structures [1]. The way in which technology is manipulated and the requirements for integrating systems depend on context of use [11], that in turn reflects the difference between needs and "wants" across different stakeholders and the actual use of technology at its full potential [12]. Ethical and legal issues related to privacy, security and liabilities, infrastructure failures, the digital divide, and low acceptance platforms [13] further add to the complexity of defining context.

3.2 Social media environment

Social media is a source that contributes to the fulfillment of information requirements; other sources include traditional media or physical sensors. Social media is the constant configuration of interactions driven by content and supported by technology [14]. The **social media environment** is where physical and digital users, content, and relationships co-create a reality driven by continuous narratives in diverse topics under the boundaries of a platform [15]. Social media is used

systematically to ask for assistance, disseminate public warnings, share multimedia, and directly engage with other users [16], creating a story of a crisis revealed when practitioners listen to the social media conversation between users [17] beyond the organizations' own social media presence [18]. Tone and sentiment of the conversation give insight into how communities and authorities perceive and respond as crises unfold. The existing social media platforms have unique features and are perceived differently by users with different goals, whether as active contributors of content (suppliers) or active listeners looking for information (seekers) [19]. Tied to the social media platform of choice **is the user's perception of privacy** and the willingness to share different kinds of information during crises knowing that their conversations are monitored.

Information types. *Text, multimedia, or a combination of formats constitute social media data.* However, if data is not enriched with contextual, time, and location features, yields incomplete information [8]. As a sense-making mechanism [16], social media use in crisis management *transforms from producing information to consuming information* [20] especially in early crisis onset. Thus, different types of information shape the story of a crisis. Raging from original, secondary, or re-sourced information classified by source; useful, sympathetic, individual, and situational information that includes sentiment as an indicator of the evolution of a crisis.

Social media users. Users in social media play other roles beyond seekers and suppliers (Table 1). The degree of influence is determined by patterns of information creation where media organizations and emergency services generate the most original content; and patterns of information sharing where individuals engaged in the conversation tend to share and re-share the most [21]. Artificially intelligent agents act in the form of bots contribute to and could influence the conversation in terms of volume, sentiment, and trends [22].

In the social media environment users receive many classifications (Table 1) which contributes to understanding the distribution, features, volume, and diversity of data present in the social media conversations. In recent years, the *influencer* concept emerged as lead users with big follower bases that use their social media knowledge to make purposeful content and manipulate the conversation. For example, a journalist who becomes a focal point in the social media conversation by initiating a source of aid through #PorteOuverte, a hashtag aiming to help the situation by matching demand and availability of shelter during the terrorist attacks in Paris [23]. Likewise, hashtags are ad-hoc identifiers or tags that, preceded by the hash sign (#) and combination of words without spaces, briefly describe a situation, event, theme, conversation, or place. Hashtags are desirable to follow conversations in social media chronologically, thematically, contextually, and systematically. Tags emerge organically by user-consensus active in the conversation or are established beforehand by influential users or crisis response entities to control the conversation. The effectiveness of hashtags is questioned because they are rarely used with novel

information [24]. However, hashtags are a mass amplification vehicle when actionable information is sensed [23].

Table 1. User classification in social media in crises

Parameter	User type
Diverse social media presence and communication roles	*Organization*: i.e. Ministry, Emergency services agencies, media, political groups, office of the president, private company. *Organization's leadership:* i.e., Minister, president, mayor, CEO. *Individual*: private citizens acting on behalf of their affiliation with an organization or as regular citizens).
Activity in conversations	*Lead*: Topmost active users. *Highly active:* Account for almost 10% of activity. *Least active users:* Making the remaining 90%.
Physical or emotional proximity to an event	*Directly affected:* Provide factual information due to their immediate involvement in the crisis. *Indirectly affected:* Distribute information and turn to social media to make sense of situations. *General public:* Generate large volumes of information that shape the overall sentiment of the conversation.
Function	*Retransmissions*: Help amplify messages. *Use-tweets:* Effective service providers or takers. *Collective assurance:* Commenters on the situation.
Eyewitnesses that recount events through social media platforms	*Direct eyewitnesses:* Report first-hand knowledge of events including perceived severity through detailed experiences, feelings, and happenings. *Indirect eyewitnesses*: Distribute information with affected family and loved ones in mind, information sharing possibly occurs across platforms. *Vulnerable eyewitnesses:* Population at risk of impeding disasters, (commonly in slow onset disasters with previous warning).

The social media environment is continuously configured by a cluster of relationships, users, behavioral and organizational patterns that manifest through content, data, and information from diverse topics, interests, and contexts. Throughout the life cycle of crises, this environment serves as a mechanism for information flow that influences online and offline crisis management actions.

3.3   SoMLIS entities in practice

SoMLIS observes the world from an augmented reality that relies on the narratives from a network where consuming and responding to content is the main driver for users [15]. The core activities of listening to the social media environment are influenced by organizational configurations, collaboration routines, and methods. Practices exist to fulfill operational objectives that lead to specific crisis management actions. Thus, the decision makers drive objective-setting within organizational boundaries [25]. In crisis management, goals and expectations are set before events occur and tend to change dynamically [9]. The required information to aid crisis management tasks may be found in the social media environment but needs to be extracted, analyzed, synthesized, and reported in a format understandable by decision makers. This calls for the configuration of a socio-technical process that ensures a

proper flow of information performed in a crisis management context (the SoMLIS practice).

In turn, "based on who is seeking information, different types of information may be broadcasted and sought depending upon the intended audience or the role of the information seeker" [26] (Table 2). The role of practitioners in communications and operations is changing [18], requiring understanding of tools for social media analytics and technical skills together with experience in the field of emergency management and public safety [12]. Thus, attitudes towards social media, originating in personal use and experience with platforms, influences the SoMLIS practices that in turn influence the delivery of crisis management services [11]. The use of different sources simultaneously and adaptability to different scenarios [9] is also desirable. Practitioners assert that young staff might bring value to the knowledge on social media and accept two-way communications as an organic process [11]; seasoned crisis managers perceive social media as a tool to find specific information such as damages, injuries, and basic needs [27].

Table 2. Information seekers in crisis management

Type	Definition
Citizens	Survivors and engaged individuals and communities affected by crises actively contribute information, make quick decisions, influence authorities' actions, and collectively help those in need. Assume the role of *first* responders in the immediate onset of a disaster.
Citizen scientists	Specialized or subject-matter-experts that contribute to collective sense-making for complex information and evidence interpretation
Digital volunteers/ humanitarians	*Spontaneous*: Surface soon after a crisis occurs, more notable in large scale disasters. *Digital*: Affiliated to an organization with defined tasks, not necessarily collaborating with official entities. *Virtual operations support teams (VOST)*: Contribute and collaborate with outsourced information gathering through social media monitoring, information verification, and crisis mapping. Have an established organizational bond and structure within emergency management agencies before a crisis occurs.
Crisis mgmt. authorities and humanitarian organizations	Typically responsible for crisis management, count with a command-and-control structure where operation center analysts or public information officers are at the core of the demanded tasks.

Spectrum of roles in practice. These dualities between crisis management expertise and technology abilities, including social media, suggest that ideal organizational configurations mix internal and external sources with a variety of capabilities. Collaboration structures that encourage flexibility, coordination, and adaptation through the implementation of a social media analyst role [28] or collaboration with other organizations and digital volunteers [29] could optimize the value of social media data in crisis management operations [3]. For example, in adapting SoMLIS

processes, organizations need support, knowledge, and experience to meet technical internal and external needs [30]. In contrast, when setting up organized volunteering teams, the structure needs such flexibility to internally organize to embed in established structures of emergency management agencies [9]. While an institutionalized relationship between traditional humanitarian institutions and digital humanitarian organizations has not been established [13], patterns of collaboration are observed with other organizations that might not have the same structural and procedural characteristics [9]. Thus, information processes, communication, dialogue, and cooperation are vital factors in institutionalizing cooperation relationships to managing crises [9].

Adopters of social media in crisis management have matured their practice configurations to include a wide spectrum of specialization. Configurations of practice range from analysts tasked with social media functions in addition to regular roles [18] to dedicated social media intelligence teams [28]. Social media functions are traditionally housed under crisis communications and more recently included in operation and tactical roles. These roles are different but not mutually exclusive [28]. However, hesitancy remains in the official recognition of social media as a valid source of information, even in organizations where the integration of social media activities is more sophisticated [11]. The value of social media in operations remains ununderstood as information leads to different actions depending on the nature of operations [31].

The decision maker. Much of the literature contributes to understanding and developing techniques for improving decision making using social media data. However, the concept of the *decision maker* is barely explained as a social entity. From the decision making processes, it is inferred that they are the final consumer of information gathered by SoMLIS practice [32] and the enabler of actions, resource distribution and dynamic objective setting [33]. The decision maker can be a sole individual, a team, or a system that combines social aspects with technology capabilities.

Technologists and technology. The realization of objectives starts with information gathering [34] that is performed with tasks intrinsically related to technology such as filtering, early warning, or visualizations [35]. Thus, technologists play a vital but often overlooked role in the ecosystem as they influences the innovation, adaptation and acceptance of technologies into practice [25]. Software developers are usually placed outside of the core organizational structures [12].

The uniqueness of crisis events in terms of magnitude, location, and type of disaster makes it difficult to predict the quantity, accuracy, and quality of data that will become available in social media [1]. Moreover, human computation of social media data is limited, demanding automatic methods, namely extraction, organization, analysis, synthesis, visualization, and reporting [35]. Nevertheless, operations carry-on with imperfect information [1]. **Technology solutions and techniques are designed to address social media data characteristics to match crisis**

management needs. However, as information requirements reach more profound levels of complexity and specificity, the design of tools to aid SoMLIS practices become more context and need dependent. As "[t]here are no universally adopted systems[…]; the use depends on context, system features, user expertise, funding for purchasing software, and a willingness to adopt new (and often experimental) technologies." [12]. **Technology approaches that seek to address SoMLIS challenges** are diverse, examples include:

- Processing content, handling information overload, classifying, and prioritizing types of information.
- Processing social media multimedia for damage identification.
- Multilingual and context specific options other than English language.

In practice, technology solutions employed in crisis management range from the adoption of tools intended for other purposes such as marketing, to custom made, or in-house developed solutions tailored to a specific context, organization, and stakeholder needs. Additional **methods and technological solutions continuously become available** as interest in social media use increases in research. However, most solutions focus on challenges experienced in the early onset of crises, particularly situational awareness and early-warning systems [36]. Only few studies focus on the continuous use of social media both during crisis and non-crisis periods [37] or the use of social media tools for other parts of the crisis management life-cycle (preparedness, recovery and long-term mitigation) [6].

With the wide availability of technology solutions some commonalities are identified. For example, the user interface is typically driven by a data visualization dashboard [35]. Behind the dashboards, the collection and filtering of information through algorithmic, artificial intelligence (AI), automatic classification, aggregation, machine learning, and deep learning techniques is carried out [9]. AI train themselves to handle specific tasks; regardless of the technique, data is preprocessed in a format understood by the mechanisms of processing and analysis [35].

There is increasing importance in processing data with **geolocation and location referencing features** that are thought to be easily automated [26]. The way solutions are created through computational methods is a combination of manual data processing and **supervised or unsupervised learning techniques** for algorithms [36]. The **robustness of technology solutions** lies in dynamically addressing as many data properties as possible, taking into account computational constraints [36].

Practitioners appreciate reporting and visualization mechanisms that present insights from social media data in a cohesive and understandable format tailored to the requirements of decision-making and subsequent actions [38]. Visual analytics, situation reports, and collaborative map displays are the preferred features to summarize findings from social media and other digital services in practice [12]. Thus, geo-located data displayed on a map, shifts in social media conversation over time, and the emergence of trends are the most popular features requested by practice.

Through the mechanisms of reporting and visualizing information emanating from social media, data seem more *digestible* for the reader [11]. Visualizations and maps act as a *one-stop-shop* for continuously updated information. Moreover, usability and

compliance with local regulations on data privacy together with spatial data infrastructure are important [8] but add an aditional layer of complexity.

Situation reports are traditionally the avenue for decision making by keeping track of the development of crises and the activities of the organizations [39]. The format of reports and communication protocols is intrinsic to the organizational, crisis, and operational context, and calls for synergy among team members and data transmission standardizations [9]. Producing reports is time-consuming, involving the format of pre-specified information protocols within the decision making process [1]. These documents contain high-level information that might lack details [1]. Urgent situation-specific information is preferably accessed directly and immediately [39].

3.4   SoMLIS and other systems

Practitioners in crisis management traditionally rely on more trusted approaches such as physical sensors, population distribution data, or remote sensing data to fulfill crisis management tasks [37]. Therefore, SoMLIS practices commonly operate as separate entities within crisis management strategies [4]. Because social media data alone might lack depth and quality [36] and it is regarded as a non-authoritative source [4]. Relying exclusively on social media data poses a risk of possible assumptions about affected areas based on a generalized picture constructed from high content production that reflects high connectivity and wealth [13]. Therefore, low-resource areas are often ignored, and social inequalities are exacerbated. The voids of social media are commonly addressed through familiar methods such as community outreach [1].There is a need to integrate different sources of information [37] ideally through fusion methodologies with architectures for triangulation, verification, and management of uncertainty [34]. However, practices count with different sets of systems with specific uses that pose a challenge when integrating social media tasks at the intra and inter-organizational levels.

4   Discussion: The building of an ecosystem

Crisis management practitioners, solution developers, and academics recognize social media's value as an information source during crises and non-crisis periods. Still, challenges remain in adopting, integrating, and improving SoMLIS practices [8,4].

We summarize our findings through a scalable model depicting the ecosystem where SoMLIS practice configurations emerge (Fig 2). However, this model is conceptual, constructed from a network perspective that calls for further validation with empirical data. In the model, the different features previously explained are illustrated as entities which interaction contributes to the achievement of a common goal under a distinctive context. Contrasting the model with empirical data could complement and emphasize the role of context in the organizational, geographical, socio-economic, environmental, and technological fronts where practices are configured and enacted.

The starting point are the objectives to be fulfilled, which can be situational awareness, two-way conversations, early warning of events or continuous monitoring.

Then, information requirements emerge, and sources of information are selected to satisfy those requirements. In this model, the *social media listening practice SoMLIS* (purple box) is the main focus; however, as referenced previously, different combinations and coordination with other information sources and organizations are encouraged for a holistic approach to satisfy the need for information (green box).
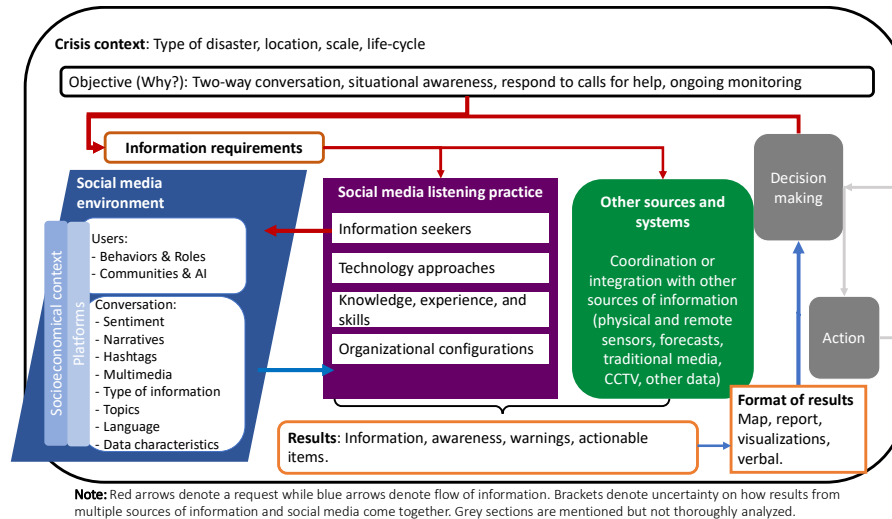

Fig. 2. The SoMLIS ecosystem in crisis management

Within the SoMLIS practice, socio-technical configurations emerge through interconnections between technology software and methodologies, personnel in charge of social media tasks, organizational structures, professional networks, knowledge, experience, and craft both from technology and crisis management and legislation. Then the SoMLIS practice interacts with the *social media environment* (blue box) that is constantly producing descriptions of realities through text and multimedia content. The SoMLIS practice provides and input in the form of a query to the social media environment. The results of the query provide a data output for further processing. The quality of the query determines the quality of information harvested and processed [35]. Here, the relevance of the technology capabilities and experience of the staff in charge is reflected in the results. The harvested information is the basis for analysis, synthesis, and subsequent reporting of the data. From the literature, it is not clear *where* or *how* other sources of information converge. Therefore, we have illustrated this gap with a bracket as an aggregated, and arguably, ambiguous representation of the results produced from different sources. Results are then presented in a format tailored to the needs of the entities who need information, namely decision makers. Formatting and customizing the delivery and visualization of information is a necessary step before reaching decision making and subsequent action that in turn formulates objectives and new information requirements.

The SoMLIS practice is cyclical and navigates through periods of crises and non-crisis that respond to intrinsic characteristics given by a context (black line). The role of context goes beyond a box that encapsules practices and interactions as the properties of the ecosystem are assigned through context. For example, socio-economic, cultural, and political, aspects of the location of incidents are observed through the social media environment and manifested both online and offline. Characteristics of the crisis are intrinsic to the type of event and the impact on the affected community which can also be observed in the social media environment. The information that is processed, analyzed, and synthesized contains context embedded that informs decisions. Moreover, practice configurations themselves carry intrinsic environmental, technical, and organizational features [8].

Within SoMLIS, processing, classifying, analyzing, and synthesizing data from social media oscillates between automated and manual processes that respond to the requirements for information. The degree in which automation and manual tasks are optimized could depend on the interplay between the practice, the crisis, and the surrounding environment. Moreover, there is room for improvement and exploration of innovative avenues to aid information extraction, analysis, synthesis, and crisis management reporting. A research approach could include closer attention to the design of socio-technical systems starting with the requirements elicitation, analysis, testing, and evaluation of SoMLIS practices [27]. Where familiarity and experience with previous crisis management operations, technical solutions, training, guidelines, legislation, and processes compared against the temporality of crises are analyzed to optimally configure and re-configure practices.

Through a review of the academic literature that analyses practices of social media use in crisis management, we identified the entities that configure the SoMLIS practice. Then, we summarized our findings by proposing an ecosystem where the SoMLIS is situated in the middle. Our approach places entities and relationships within practice that acquire properties through the different realms or facets of context. Our results call for further validation and analysis with empirical data.

References

1. Tapia, A.H., Moore, K.: Good Enough is Good Enough: Overcoming Disaster Response Organizations' Slow Social Media Data Adoption. Comput Supported Coop Work **23**(4), 483-512 (2014).
2. Olteanu, A., Vieweg, S., Castillo, C.: What to Expect When the Unexpected Happens: Social Media Communications Across Crises. 18th ACM CSCW, 994–1009 (2015).
3. Hughes, A.L., Tapia, A.H.: Social Media in Crisis: When Professional Responders Meet Digital Volunteers. jhsem **12**(3), 679-706 (2015).
4. Ehnis, C., Bunker, D.: Repertoires of collaboration: incorporation of social media help requests into the common operating picture. Behav. Inf. Technol. **39**(3), 343-359 (2020).
5. Okoli, C., Schabram, K.: A guide to conducting a systematic literature review of information systems research. (2010).

6. Anson, S., Watson, H., Wadhwa, K., Metz, K.: Analysing social media data for disaster preparedness: Understanding the opportunities and barriers faced by humanitarian actors. Int. J. Disaster Risk Reduct. **21**, 131-139 (2017).

7. UNDRR: Sendai Framework for Disaster Risk Reduction 2015–2030. 3rd UN World Conference on DRR, 14-18 (2015).

8. Stieglitz, S., Mirbabaie, M., Fromm, J., Melzer, S.: The Adoption of social media analytics for crisis management–Challenges and Opportunities. 26th ECIS **4** (2018).

9. Fathi, R., Thom, D., Koch, S., Ertl, T., Fiedrich, F.: VOST: A case study in voluntary digital participation for collaborative emergency management. Inf. Process. Manage. (2019).

10. Bruns, A., Stieglitz, S.: Quantitative Approaches to Comparing Communication Patterns on Twitter. Journal of Technology in Human Services **30**(3-4), 160-185 (2012).

11. Reuter, C., Kaufhold, M.-A., Spahr, F., Spielhofer, T., Hahne, A.S.: Emergency service staff and social media – A comparative empirical study of the attitude by emergency services staff in Europe in 2014 and 2017. Int. J. Disaster Risk Reduct. **46**, 101516 (2020).

12. Hiltz, S.R., Hughes, A.L., Imran, M., Plotnick, L., Power, R., Turoff, M.: Exploring the usefulness and feasibility of software requirements for social media use in emergency management. Int. J. Disaster Risk Reduct. **42**, 1-14 (2020).

13. Burns, R.: Rethinking big data in digital humanitarianism: practices, epistemologies, and social relations. GeoJournal **80**(4), 477-490 (2015).

14. Cohen, H.: Social Media Definition: The Guide You Need To Get Results. In: Heidi Cohen: actionable marketing guide, vol. 2020. vol. October 14. (2020)

15. Pond, P.: The space between us: Twitter and crisis communication. IJDRBE **7**(1), 40-48 (2016).

16. Stieglitz, S., Mirbabaie, M., Schwenner, L., Marx, J., Lehr, J., Brünker, F.: Sensemaking and Communication Roles in Social Media Crisis Communication. Wirtschaftsinformatik, (2017)

17. Meesters, K., van Beek, L., Van de Walle, B.: # Help. The Reality of Social Media Use in Crisis Response: Lessons from a Realistic Crisis Exercise. In: 49th HICSS 2016, pp. 116-125

18. Hughes, A.L., Palen, L.: The Evolving Role of the Public Information Officer: An Examination of Social Media in Emergency Management. jhsem **9**(1) (2012).

19. Purohit, H., Hampton, A., Bhatt, S., Shalin, V.L., Sheth, A.P., Flach, J.M.: Identifying seekers and suppliers in social media communities to support crisis coordination. CSCW **23**(4-6), 513-545 (2014).

20. Reuter, C., Marx, A., Pipek, V.: Crisis management 2.0: Towards a systematization of social software use in crisis situations. IJISCRAM **4**(1), 1-16 (2012).

21. Mirbabaie, M., Ehnis, C., Stieglitz, S., Bunker, D.: Communication roles in public events. In: Working Conf. on Information Systems and Organizations 2014, pp. 207-218

22. Brachten, F., Mirbabaie, M., Stieglitz, S., Berger, O., Bludau, S., Schrickel, K.: Threat or opportunity? - Examining social bots in social media crisis communication. Australasian Conference on Information Systems (2018).

23. He, X., Lu, D., Margolin, D., Wang, M., Idrissi, S.E., Lin, Y.-R.: The signals and noise: actionable information in improvised social media channels during a disaster. ACM on Web Science Conference, 33-42 (2017).

24. Saleem, H.M., Xu, Y.S., Ruths, D.: Novel Situational Information in Mass Emergencies: What does Twitter Provide? Humanitarian Technology: Science, Systems and Global Impact **78**, 155-164 (2014).

25. Olteanu, A., Vieweg, S., Castillo, C.: What to Expect When the Unexpected Happens: Social Media Communications Across Crises. 18th CSCW, 994–1009 (2015).

26. Vieweg, S., Hughes, A.L., Starbird, K., Palen, L.: Microblogging during two natural hazards events: what twitter may contribute to situational awareness. SIGCHI 1079-1088 (2010).

27. Kaufhold, M.-A., Rupp, N., Reuter, C., Amelunxen, C.: 112.Social: Design and evaluation of a mobile crisis app for bidirectional communication between emergency services and citizens. 26th ECIS (2018).

28. Power, R., Kibell, J.: The social media intelligence analyst for emergency management. 50th HICSS (2017).

29. Bonaretti, D., Piccoli, G.: Digital Volunteers for Emergency Management: Lessons from the 2016 Central Italy Earthquake. 24th AMCIS (2018).

30. Latonero, M., Shklovski, I.: Emergency management, Twitter, and social media evangelism. IJISCRAM **3**(4), 1-16 (2011).

31. Purohit, H., Castillo, C., Imran, M., Pandey, R.: Ranking of Social Media Alerts with Workload Bounds in Emergency Operation Centers. IEEE/WIC/ACM International Conference on Web Intelligence, 206-213 (2018).

32. Backholm, K., Ausserhofer, J., Frey, E., Larsen, A.G., Hornmoen, H., Hogvag, J., Reimerth, G.: Crises, rumours and reposts: rournalists' social media content gathering and verification practices in breaking news situations. Media Commun. **5**(2), 67-76 (2017).

33. Pogrebnyakov, N., Maldonado, E.: Didn't roger that: Social media message complexity and situational awareness of emergency responders. IJIM **40**, 166-174 (2018).

34. Conrado, S.P., Neville, K., Woodworth, S., O'Riordan, S.: Managing social media uncertainty to support the decision making process during emergencies. Journal of Decision Systems **25**(sup1), 171-181 (2016).

35. Imran, M., Castillo, C., Diaz, F., Vieweg, S.: Processing social media messages in mass emergency: A survey. ACM CSUR **47**(4), 1-38 (2015).

36. Wang, Z., Ye, X.: Social media analytics for natural disaster management. Int. J. Geogr. Inf. Sci. **32**(1), 49-72 (2018).

37. Henriksen, H.J., Roberts, M.J., van der Keur, P., Harjanne, A., Egilson, D., Alfonso, L.: Participatory early warning and monitoring systems: A Nordic framework for web-based flood risk management. Int. J. Disaster Risk Reduct. **31**, 1295-1306 (2018).

38. Calderon, N.A., Arias-Hernandez, R., Fisher, B.: Studying animation for real-time visual analytics: a design study of social media analytics in emergency management. 47th HICSS, 1364-1373 (2014).

39. Markenson, D., Howe, L.: American Red Cross Digital Operations Center (DigiDOC): An Essential Emergency Management Tool for the Digital Age. Dis. Med. Public Health Preparedness **8**(5), 445-451 (2014).