Cross-Boundary Information Sharing Flows in Emergency Management:

Proposing a Conceptual Framework

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ABSTRACT

Given that information plays a decisive role in emergency management, scholars have been interested in how government agencies, first responders, and the general public could effectively acquire and disseminate emergency-related information. Existing research has made significant contributions in distinguishing various types of information-sharing flows (i.e., Citizen to Government, Government to Government, Government to citizen, and Citizen to Citizen). However, a holistic understanding of who the main actors are, why they share information, what specific content is shared, and what some of the main results are is lacking. This study contributes to fill this gap by proposing a framework that identifies and characterizes the critical components of information sharing in emergencies as well as some of their relationships. By analyzing the literature, we found that the characteristics of the actors, the phase of the emergency management life-cycle, and the communication channels are factors shaping information sharing activities, including willingness to share and the specific content being shared. In addition, information sharing could have a heterogeneous impact on the effectiveness and efficiency of emergency management practices, depending on the quality of the information being shared among multiple actors. The short-term results could also affect the satisfaction of the involved stakeholders and further influence information sharing in the long run. Finally, a few questions that deserve further investigation are identified.

CCS CONCEPTS

• **Applied computing** → Computers in other domains.

KEYWORDS

Information sharing, Communication, Citizen-government Collaboration, Emergency management

1 INTRODUCTION

Information sharing, understood as disseminating and exchanging information among involved individual and organizational actors, plays a crucial role in emergency management, encompassing the preparation before, response during, and recovery after natural or human-caused emergencies. In particular, the way stakeholders share information has been fundamentally reinvented due to the advancement of information and communication technologies (ICTs), such as information systems and Web 2.0 applications. Previous literature has investigated the type of actors who exchange information and the content of the shared information on emergency response and recovery. In terms of actors, existing emergency management studies have identified different types of information interactions and flows among different actors [23, 27]. In general, four categories of information flows are apparent: (1) government to citizens, (2) citizens to citizens, (3) citizens to government, and (4) government to government. In addition, studies focusing on a specific information flow have revealed its specific content and how useful each flow is during emergencies [8, 22, 32].

However, the current knowledge of information sharing flows in emergency management is limited in several ways. First, why the actors share and receive information is not well-understood [10]. The willingness of actors to participate in information sharing determines whether the critical information will be transmitted among relevant actors and thus is as important as the shared content. Second, the results of each information flow on emergency management capacity and the underlying mechanisms of how these results take place are far from clear. Third, most of the existing studies only focus on a single flow of information sharing or a single
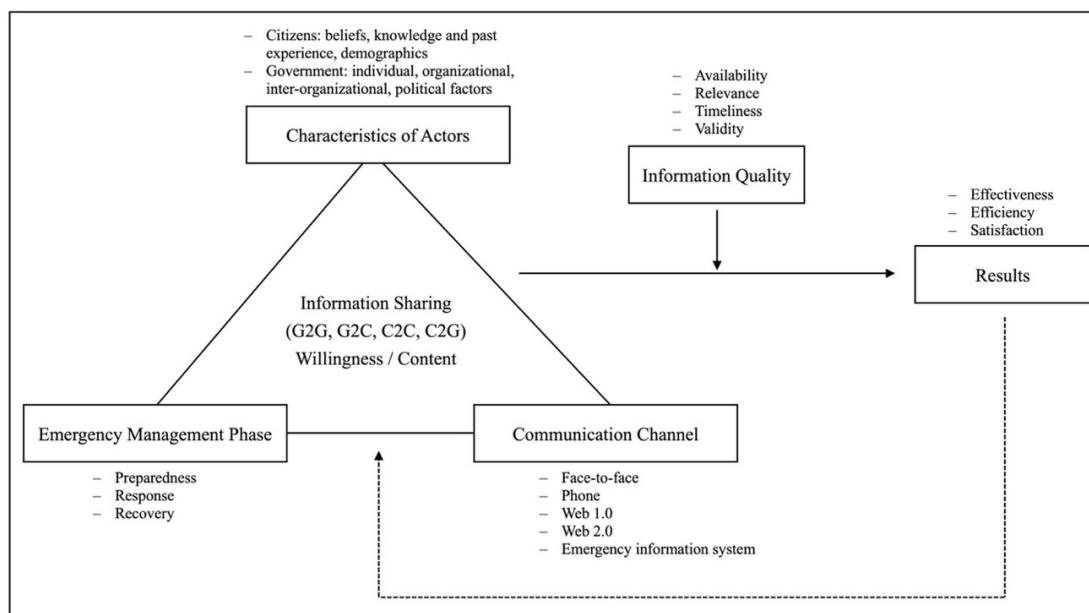
Figure 1: A Framework of Cross-Boundary (Individual and Organizational) Information Sharing in Emergency Managements. (Source: Authors)

stage of emergency management, resulting in a fragmented understanding of cross-boundary information sharing over the course of a crisis.

Given these gaps, this paper aims to build a framework that explains the flows of information among actors in emergency situations with the ultimate goal of informing future empirical studies and practice. We seek to generate a comprehensive understanding of the critical components of information sharing flows in emergencies to explain (1) the role of different actors, (2) what specific information is being shared as well as how it is being shared, and (3) how all information flows taken together contribute to a better understanding of the emergency situation and improve coordination among different actors.

The remainder of this paper is structured as follows. Section 2 briefly describes our methodological approach. Section 3 illustrates the proposed framework of emergency management information-sharing flows, including the main components and relationships among them. Section 4 proposes a few implications for future research and practice. Finally, Section 5 provides some concluding remarks and suggests ideas for future research.

2 METHODOLOGICAL APPROACH

A narrative literature review was conducted to answer our research questions because it enables us to examine the current state of knowledge, identify research gaps, and contribute to the current conversation [15]. In terms of the procedure, we first used keyword combinations such as ("information sharing") AND ("emergency management" OR "disaster management") to search for related literature, including journal articles, book chapters, and conference

proceedings, via the Web of Science (WoS) search engine. Thirty-one publications were found after the search. Then, we paid close attention to each article and documented the key information presented in the empirical or conceptual studies, including the main actors, the stage of the emergency management cycle, the form used for interactions, the primary results of information sharing, as well as the determinants of those results. We then organized the findings into a systematic cross-boundary information-sharing framework that illustrates the main factors influencing various information-sharing flows in the context of emergency management. The findings are described in the next section.

3 THE CROSS-BOUNDARY INFORMATION SHARING FRAMEWORK

Our proposed framework is illustrated in Figure 1. We identified three major components – characteristics of the involved actors, emergency management phase, and communication channel – that may influence the actors' willingness to share information as well as the actual content they share. In addition, cross-boundary information-sharing may lead to different results for emergency management. In the following paragraphs, we further explain these components and some of their interrelationships.

3.1 Characteristics of the Actors Involved

Research indicates that the characteristics of the actors involved – including some cognitive and behavioral aspects of participants as well as the context they are situated in – play a vital role in exchanging crisis-related information. Recognizing the involved parties' characteristics is important because it helps avoid making incorrect assumptions about the expected behavior of people,

which may cause emergency management planning to fail [1, 29]. Regarding the citizens or general public, their beliefs, knowledge and past experience, as well as certain demographics are crucial aspects to consider.

- **Beliefs**: When facing emergencies, it is noted that individuals are interested in their own well-being, safety, and security as well as their family, friends, and neighbors [10, 11, 13, 19]. This could be the result of different reasons such as rational egoism, the social connectedness with the community, or altruism [8]. In addition, residents consider that they have exceptional information about emergency conditions that may be useful to governments [11]. Accordingly, citizens wish to engage in information-sharing activities with other citizens and government authorities to reduce their concerns and help others [10, 11]. Motivated by these beliefs, studies find that the public will comment on the government's plans and actions, seek answers to questions, provide information about resources available in the community, report first-aid needs and damage conditions, and find missing relatives and friends [12, 13, 16, 31]. Nevertheless, successful communication between governments and citizens depends on citizens' level of trust in government agencies [25].

- **Knowledge and past experience**: It is suggested that citizens are the first responders in any emergent situation, and thus their knowledge of the conditions could be conducive to improving government agencies' situational awareness and actions [8, 11]. In addition, the public can be further categorized into different roles, each of which may possess various kinds of knowledge to help the community manage disasters [19, 20]. Díaz et al. [8] argue that, depending on the reliability and experience of the information producer, citizens can become trusted sensors by having experience and credibility accredited by emergency management authorities. Furthermore, those with specialized knowledge of an event can serve as nodes, providing detailed and precise information. Lastly, experienced citizens can also be potential agents, who can execute some actions under government's supervision. Studies show that some government agencies find it helpful to develop and train observers, leaders, or field workers, within a community so that they can be essential and credible human resources when dealing with emergencies [32].

- **Demographics**: Citizens' demographic characteristics affect their information-sharing behaviors too. Considering that technology has gradually become a dominant means for receiving and transmitting information in recent decades, the geographic and educational digital divides may prevent certain populations from participating in information exchange. For instance, remote and less developed places and less affluent and less educated people face more challenges in accessing information technology, thus being potentially excluded from the circulation of critical disaster information [12]. Also, it is indicated that women and younger people communicate more frequently via phone or text and social media messaging than men and the elderly in extreme weather events [28], which could also affect the information they receive.

As for the government, multiple studies show that its information-sharing behavior is influenced by individual, organizational, inter-organizational, and political factors.

- **Individual factors**: Studies find that first responders prefer to reduce information overload by avoiding things unrelated to dealing with the crisis, given the high uncertainty and time pressure of an emergency [2, 31]. Also, first responders find it challenging to decide what needs to be shared, how to access and precisely interpret information, and how to confirm and maintain information quality [2] in a way that can help minimize risks and maximize efficiency [1]. Research indicates that first responders recognize the value citizens can bring to the decision-making and execution process, thereby being more open to citizens' involvement [32]. Another reason for first responders to communicate with citizens is to show how their efforts generate value for the community [10]. Hence, depending on their perceptions toward other stakeholders and evaluations of the value of information sharing, first responders' willingness to share and seek information may vary significantly.

- **Organizational factors**: The organizational behavior in exchanging crisis information is considerably affected by values and norms. Research finds that the values of efficiency, expertise, and control are highly prioritized over the course of emergency management [1, 4, 16]. To these ends, first responders rely on a command-and-control system and organizational procedures to articulate the roles, tasks, and responsibilities of each person, as well as standards and rules that need to be followed [2]. Such features will impede the organization's capability to share information with other agencies and external actors, including citizens [14].

- **Inter-organizational factors:** As emergencies may involve multiple agencies within the same government or across jurisdictions, the interconnectedness among agencies will impact their joint capability to address emergencies. Numerous elements that may influence inter-organizational collaboration have been identified. One factor is that the organizations simply do not have a sense of the overall operational dependencies among the agencies [2], and thus do not understand which parties they should contact. Another is that each agency's goals, roles, and responsibilities may be in conflict with each other [2], making it difficult to exchange and coordinate information for better decision-making. Besides, even when there is a cooperation agreement, the organization may still feel hesitant about collaboration since a misalignment could happen between the cooperation procedures and its own practices, resulting in the loss of autonomy, control, and efficiency [1]. Finally, the fact that each organization may own a different system or structure for information exchange may pose a challenge related to standardization and interoperability, which serve as a bedrock for inter-agency information sharing [2, 23, 29]. In sum, the knowledge, level of alignment, and degree of interoperability

collectively contribute to the inter-organizational dynamics, which, in turn, affect the sharing of information among government agencies in emergencies.

- **Political factors:** Since government organizations are embedded in a more extensive political system, politics will have a direct impact on public authorities' decisions. Research finds that a political leader's perception of citizens' role in emergency management determines whether and to what extent the government interacts with citizens [16]. In addition, political leaders may be unwilling to receive input from the citizens because of political party competition [16]. Furthermore, it is found that politicians often feel inclined not to lose any autonomy in their decisions [1], which would make the organization less likely to communicate with other involved parties. Lastly, political support for emergency management, for example, in the form of programs and funding, is vital for establishing a plan for exchanging useful information with different stakeholders. In short, a political leader's viewpoint, political competition, and political support are crucial elements underlying information sharing between one agency and other government and non-government actors.

3.2 Emergency Management Phase

Research also indicates that the phase of emergency management influences cross-boundary information sharing. There are three stages in a typical emergency management cycle [24]: preparedness, response, and recovery. Each stage has a set of activities performed by various stakeholders [29]. Research suggests that, depending on the stage of an emergency, governments may place varying weight on the decision of whether and to what extent governments and first responders should engage in information exchange activities with citizens [32]. Such variation results from the fact that the government usually adopts a command-and-control system to prepare and respond to an imminent threat and expects citizens to passively receive information and closely follow its directions. In contrast, recovering from a disaster requires more input from the local communities, thereby leading the government to interact with residents and engage in two-way communications more frequently.

Besides the willingness to share information, the distinct goals and tasks in each stage also imply different information needs. For example, in the preparedness phase, citizens can share with each other useful information to help the community develop a preparation plan through meetings, newsletters, and emails and set up communication channels for exchanging information during an emergency event [19]. As for the government-citizen interactions, it is suggested that residents will share their household situation and personal information with the authorities so that the government can better understand who lives in the area and their potential needs. On the other hand, the government can disseminate multiple types of information to the community, such as instructions for individual and family preparedness, guidance on how to take care of special populations, the contact information of community emergency response teams and neighborhood watch, the tools available for

communication, the survival guide for local businesses and nonprofit organizations, and guidance on how to donate and volunteer when an emergency happens [25].

In the response phase, the communication among the governments and first responders mainly involves the data on risk, resources, roles, and responsibilities, which are conducive to enhancing situational awareness and inter-organizational coordination [7, 23]. Additionally, the citizen-to-citizen and citizen-to-government information-sharing flow usually encompass such information as local resources, first-aid needs, the status of the event, fears and concerns, questions, and comments on the government's response efforts [5, 9, 11, 12, 23]. Regarding the communication from government to citizens, the information usually includes the status of the event, necessary actions that citizens need to take, the responses made by the government, community appraisal, rumor prevention and clarification, and seeking information [21–23, 26]. During the recovery stage, the communication channel found in the literature is primarily between government and citizens. It is suggested that citizens in the affected communities would comment on the government's activities, express gratitude, and raise questions or concerns, and the government would seek communities' needs and regularly provide the latest updates on the recovery [13, 16, 32].

3.3 Communication Channel

An abundance of research has been devoted to examining the exchange of information among actors through various channels in emergencies. Studies identified that citizens and governments share and access information in a broad spectrum of ways, such as face-to-face, phone calls, text messages, web pages, social media, and emergency information systems [17, 18, 28]. In particular, as Web 2.0 technology becomes increasingly popular, social networking has facilitated government-to-citizen, citizen-to-government, and citizen-to-citizen communications. Research finds that, in general, a majority of citizens use social media, like Twitter and Facebook, to seek information instead of a web page [18]. Besides, when receiving an emergency warning alert from the authorities, citizens are more likely to share information via a phone call, text messaging, and Facebook than an in-person conversation [18].

On the government side, social media has made it convenient for public authorities to share with and collect information from citizens instantly [4, 21, 22]. Nevertheless, social media also generates new challenges for the government, mainly the circulation of incorrect information and the exposure to an excessive amount of data [4]. Concerning inter-organizational cooperation, establishing an information system with a proper design can help involved organizations better coordinate their efforts [3, 14]. It is found that the user's intention to use a disaster management information system is determined by the expected value of how the system can contribute to the teamwork and support one's tasks [3, 17]. In a nutshell, an information system for emergency management should support multi-directional communication, ensure information richness and timeliness, and help link relevant data [31]; it should also help avoid information overload, inaccuracy, and conflicts [29].

3.4 Results

Research indicates effectiveness and efficiency in the preparedness, response, and recovery stages are two of the most important results of information sharing for emergency management. Effectiveness can be understood as the degree to which information sharing activities successfully produce the desired result, such as detecting and mitigating risk, increasing situational awareness, securing personal and property safety, and building up community resilience [4, 6–8, 19, 30]. As far as efficiency, it could be conceived as the ability to produce good outcomes without wasting time and physical resources [4, 7, 26]. In the longer term, the efficiency and effectiveness achieved by collaboratively sharing information will be translated into citizens' and government officials' perceptions and satisfaction [16], which, in turn, will influence the decisions on whether to participate in exchanging information and what specific content to share again in the future [25, 32], as captured by the feedback loop in Figure 1

Existing studies propose several criteria that the information should meet in order to manage emergencies effectively and efficiently. Within a wide variety of data quality standards identified in the literature, four dimensions are most mentioned: availability, relevance, timeliness, and validity. Availability concerns whether a critical piece of information can be accessed by the actors [4, 30, 31]. Relevance refers to what degree the information can help inform actors of the characteristics of a specific situation [29, 31]. Timeliness is whether the provided information is up-to-date and received when it is the most useful [4, 30, 31]. Finally, validity can be defined as the accuracy of the data [12, 31]. It seems clear that the four information quality criteria are relevant for all types of information-sharing flows and are directly or indirectly affected by the identified variables related to the participant's characteristics, the specific phase of the emergency management cycle, as well as the communication channel or channels being used. Furthermore, the quality of information contributes to effectiveness and efficiency. In addition, as information can be freely exchanged among parties and is relevant, up-to-date, and valid, situational awareness and coordination can be significantly improved, leading to a successful design and implementation of emergency management plans.

4 IMPLICATIONS FOR RESEARCH AND PRACTICE

First, we find that the characteristics of involved government and non-government actors impact information sharing. In particular, we added insights into the citizens' role in emergency management, showing that citizens are not identical entities but could be heterogeneous based on their knowledge and experiences. While a similar nuanced differentiation in the government actors was not presented within the literature, we believe that the roles and functions of government organizations could be diverse too. For instance, first responders should be different from emergency management agencies coordinating their efforts or other government agencies involved in a response. Moreover, the patterns of local businesses and non-profit organizations in sharing information with other entities are also underexplored. The insights pave a new way for considering a multiplicity of actors engaging in exchanging information in emergency situations. Instead of viewing citizens

and the government as homogeneous categories. Future scholars and practitioners should acknowledge the diversity of governments, citizens, private companies, and non-profits and further explore how the information sharing flows may differ among them.

Second, the specific phase in the emergency management cycle is another factor affecting cross-boundary information sharing. Nevertheless, little has been known about the differences in participants, their roles, and the communication methods they prefer across the three stages. As we highlighted in the former discussion, different citizens and government agencies may possess different levels of willingness and capability to participate in information exchange in emergencies. We believe that these differences could also be present under various stages of emergency management. Therefore, it would be useful to identify which channel a specific actor prefers to communicate in each of the different stages. In particular, most research on emergency management has focused on the preparedness and response stages, and little has been said about information sharing during the recovery stage. However, as one of the main goals during the recovery phase is to better prepare for the next emergency, information sharing still matters during this stage for government agencies, first responders, residents, and other actors to work together in improving community resilience.

Third, we show that communication channels also shape information sharing in emergencies. It is shown that the use of communication channels could vary depending on user characteristics, such as geographical area, age, gender, and their expectation of the channel's value. As such, there is not a one-fit-all communication method for every involved actor. Future studies should consider subpopulation's communication channel preferences to better assess how they may create barriers for different types of citizens and other actors to obtain critical information.

Finally, the framework identified some results of information sharing and the mechanisms underlying information sharing and its results. We find that, in general, little attention has been paid to assessing information quality and results. Most studies on information quality are conceptual, and studies do not elaborate on results. In addition, there is a lack of long-term evaluations of the effects of information sharing in emergency management. Future research could contribute to these gaps by probing how government agencies, first responders, and citizens evaluate the effectiveness, efficiency, and satisfaction of information sharing and how perceptions and interpretations of achieved results reshape different information-sharing flows.

5 CONCLUDING REMARKS

This study provides a comprehensive view of the critical components affecting information sharing flows in emergency management. To this end, we analyzed the literature on information sharing in emergency management and proposed a framework that includes some of the most critical variables and their interrelationships. As scholars acknowledged that emergency management is dynamic, complex, and requires a network approach to realize the expected benefits [14], our work helps characterize the complexities into a simplified framework that helps make sense of various types of information sharing flows. Several gaps identified in this study can help the academic community further investigate the nuances of

information sharing in emergency preparedness, response, and recovery. Some of the insights could also assist involved parties with building up and improving information-sharing flows for emergency management in real-world situations.

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