Understanding the Determinants of Adoption and Use of Information and Communication Technologies for Emergency Management: Proposing a Research Agenda based on Existing Academic Literature

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Abstract

Emergency management has been a very important and relevant topic in the 21st century as both urban and rural areas face serious challenges related to an increase of natural disasters as well as man-made emergencies. Advanced information and communication technologies (ICTs) have been one of the key tools to improve action in the different phases of the emergency management life cycle. This study aims to provide an overview of key determinants of ICT adoption and use in emergency management and proposes a research agenda for the future. Based on a comprehensive review of existing literature, this paper identifies multiple determinants at the individual, organizational, and contextual levels that influence ICT adoption and use for emergency management. Overall, the review concludes that specific determinants associated with the unique needs of emergency management and with particular features of rural areas require more attention in future research.

1. Introduction

Both natural and man-made large-scale disasters have increasingly caused devastating losses in terms of human lives and financial resources. From 1980 to 2011 in the U.S., more than 250 weather and climate disasters have occurred, each of which has cost over 1 billion dollars, and combined, totaling $1.7 trillion [52]. Rural areas with their social and economic composition, are uniquely vulnerable to emergencies both small and large-scale [47]. While rural areas are critically important for the U.S. population due to their roles in the production of food, water, and energy, the available resources to tackle disruptive emergencies still seem insufficient compared to their urban counterparts [44].

Facing the facts and foreseeable future of increasing number and scale of disasters, it is critically important to further strengthen the capability to prevent and respond to emergencies in either urban or rural areas. Emergency management or disaster management can be understood as "a complex and multi-disciplinary process of planning and implementing measures that aim at preventing risks of disasters and enabling effective response whenever an undesirable event occurs" [6]. A broad framework including four phases of emergency management has been developed to guide practices since 1980s, namely mitigation, preparedness, response, and recovery [48]. According to the FEMA guideline [21], *mitigation* refers to actions taken to prevent or reduce the cause, impact, and consequences of disasters. It requires hazard risk analysis and the application of strategies to reduce the likelihood that hazards will become disasters. *Preparedness* includes planning, training, and educational activities that help individuals and communities get ready. *Response* includes any actions taken during or immediately following an emergency, including efforts to save lives and to prevent further property damage. Ideally, disaster response involves putting already established disaster preparedness plans into motion. *Recovery* happens after damages have been assessed and involves actions to return the affected community to its pre-disaster state or better and ideally, to make it less vulnerable to future risk. However, such a process often faces several challenges caused mainly by the complex nature of disasters, such as lack of situational awareness, ineffective resource management, lack of large-scale coordination mechanisms, and lack of strong data analytical capabilities for decision-making [32, 42].

In parallel, scholars and practitioners have long argued for the important role played by information and communication technologies (ICTs) in emergency management to overcome the aforementioned challenges [19, 36]. For instance, scholars suggest that geographic information system (GIS) and remote

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sensing (RS) technologies are one of the fastest means of acquiring the necessary data for pre and post disaster assessment and are used by first responders to assess damage in a timely manner and to increase their situational awareness for response action [2, 5]. Other studies show that Emergency Management Decision Support Software (EMDSS) provides a common operation platform, situational information analysis, and resource management support to more effectively coordinate personnel and resources across multiple agencies and make in-time adjustments to the changing response demands during large-scale disasters [32]. Some scholars also find that collaborative data analytics (CDA) platforms, providing data management, information sharing, and computational modeling, help emergency management agencies to process, analyze, and understand complex and diverse information about health characteristics, demographics, location, and even the economic data of impacted citizens for appropriate decision making during response [56]. Recently, social media and crowdsourcing platforms have also been recognized as useful tools for emergency management agencies to collect up-to-date information about rapid-changing emergency situations from citizens, to adapt to their various response demands, and to keep communicating with citizens during emergencies [4, 25].

Despite the great potentials of various ICTs identified in emergency management, scholars have also noticed that adoption and use of ICTs are still lagging behind or do not often reach its full potential for effective emergency mitigation, preparedness, response, and recovery [6, 48]. This suggests the presence of certain challenges or barriers to ICT adoption and use in emergency management agencies. To further realize those potential advantages of ICTs, it is important for those agencies to further understand a comprehensive picture of those determinants influencing ICT adoption and use in emergency management.

While there is a need to further understand critical determinants, current literature specifically focusing on ICTs in emergency management is limited [46]. Although previous studies have examined ICT adoption and use in other fields of public services, participation, and collaboration [18, 57], scholars have advocated that more research is needed to provide a comprehensive insight into crucial determinants that influence ICTs for emergency management functions and phases [32, 48]. This study, therefore, aims to analyze different types of determinants that influence the adoption and use of ICTs in the phases of emergency management. The research question that guides this study is: what are the main determinants that influence the adoption and use of ICTs in emergency management? In this study, adoption and use are used interchangeably, and in general refer to the application of ICTs in agencies for one or multiple emergency management phases. This approach aligns with the way to use the two terms in current literature about ICTs in emergency management [27, 59].

To answer this question, we have conducted a literature review to identify plausible determinants that affect the adoption and use of ICTs in emergency management. Section 2 describes the literature review process. Section 3 reports the results of the review. Results are briefly discussed in Section 4. We conclude in Section 5 by proposing a future research agenda.

2. Research approach

For this literature review, we conducted two rounds of literature search. First, multiple online databases have been included to locate relevant literature and studies. These databases were Academic Search Complete, Applied Science and Technology Source, Business Source Complete, Library, Information Science and Technology Abstracts, Public Administration Abstracts, Social Sciences and Sociological Abstracts, Communication and Mass Media Complete, Wiley Online Library, the ACM Digital Library, and Web of Science. The following key terms were searched in the field of abstract that combined ICTs, e-government, determinants/barriers, adoption/implementation, mitigation/preparedness/response/recovery, and emergency/disaster. Both empirical and theoretical studies published in English from peer-reviewed journal articles, conference papers, books, and other documents were included. Articles in this review are published between 2000 and 2019. This round of search resulted in 2,219 articles after dropping duplicated hits.

Second, to find papers more relevant to ICT adoption and use by government organizations for emergency management, Digital Government Reference Library (DGRL, version 15.5) was searched using key terms of emergency/disaster. DGRL is a reference database developed by the Information School at University of Washington containing over 12,000 references of predominantly English-language, peer-reviewed work in the study domains of digital government. The database includes papers from core journals (e.g. Government Information Quarterly) and from core conferences (e.g. HICSS and dg.o) focusing on e-government. This round of search resulted in 68 papers. In total, the two-round preliminary literature search resulted in 2,287 articles.

To select most relevant papers, authors first filtered the results by reading titles and abstracts. Further, the whole paper was scanned for those papers that were difficult to decipher. The filter process excluded articles (1) about emergency management systems in general; (2) about technology systems for healthcare, patient management, or hospital management, but included

papers about healthcare in emergency situations; (3) about technology systems design. Eventually, 70 articles were included to the next step of review and analysis. The analysis of those studies focused on the adoption and use of ICTs in emergency management and determinants influencing these processes.

3. Determinants of ICT adoption and use in emergency management

Our review shows that there are multiple determinants that influence adoption and use of ICTs for specific emergency management phases or functions. Further, our results indicate that these determinants can be classified in three groups: individual, organizational, and contextual determinants. Table 1 reports main determinants of each category found in the literature.

3.1. Individual determinants

The individual determinants refer to individual capabilities, knowledge, perceptions, and experiences that influence personal relationship with ICTs. Studies find that performance expectancy, effort expectancy, and knowledge and skills influence the adoption and use of ICTs in emergency management.

3.1.1. Performance expectancy. Performance expectancy (or perceived usefulness), in general, refers to the users' perception about the capability or relative advantages of ICTs to support their own tasks and missions [18, 57]. For emergency management in general, Lee et al. [37] find that perceived group value of ICTs for multi-agency disaster response performance, rather than perceived task support for individual agency, is a more important determinant to drive organizations' ICT adoption. Instead, for emergency response, studies show that performance expectancy of ICTs in assisting first responders' individual tasks of relief operation drives the adoption of ICTs [17, 33]. Other studies emphasize that the positive perceptions of volunteer geographic information systems (VGI) in improving exchanging diverse local information and coordinating multiple agencies during hazards fire, flood, storms, cyclones, and earthquakes motivates emergency management agencies to adopt them [27].

Perceived information quality produced by ICTs seems one of the major determinants that influence performance expectancy, since accurate information about disaster scene is critical for first responders to effectively allocate resources for timely response [46, 49]. Government organizations are more likely to use VGI when their staff perceive information in VGI as trustworthy and when its use does not imply any risk or any loss of efficiency in communication in emergency situations [27, 29]. Other studies on social media or crowdsourcing platforms also find that emergency managers may not have confidence in the accuracy, credibility, and liability of non-expert produced data and are reluctant to utilize unverified data for decision-making during emergency response [11, 25, 41]. Rumors or false information on social media, either accidentally or deliberately, are perceived as a threat to public safety in a crisis [13, 45].

3.1.2. Effort expectancy. Effort expectancy (or perceived ease of use) may seem more important than performance expectancy to influence the adoption and use of ICTs in emergency management. Effort expectancy captures the degree to which a person believes a system will be complex and difficult to learn or relatively free of effort [57]. Perceived complexity of ICTs may develop anxiety and lead to resistance toward the adoption of ICTs, despite disaster relief practitioners are aware of their advantages [1, 33]. Jennings et al. [32] find that in the most vulnerable community, the benefits of EMDSS in coordination during complex emergency responses may not be strongly evident to emergency managers who deal with local small-scale disasters. Instead, they are more aware of the complexity of the system and feel overwhelmed by the required effort to adopt EMDSS. Given the higher level of perceived effort and lower level of performance expectancy, they are more reluctant to adopt EMDSS.

Several scholars argue that perceived task-technology fitness becomes an important determinant of performance and effort expectancy of new ICTs for emergency management [51]. Perceived task-technology fitness, in general, refers to the extent to which individuals perceive the ICTs adopted fit their tasks and roles in emergency management agencies [2, 58]. Ahmed and Sugianto [3] show how RFID fits four task characteristics of emergency management (authentication, automation, tagging or tracking, and information management) results in higher compatibility and lower cost to adopt and use RFID in the whole life cycle. Such new mobile technologies are perceived by staff in emergency room to have compatible data formats or interfaces with existing operation systems so that staff can easily transmit information within organizations for effective emergency response [3, 15]. Contrarily, due to the lack of compatibility with their preferences and experience, firefighters may find it challenging to effectively utilize novel firefighter information systems [60]. Given emergency management has to deal with unpredictable situations, scholars argue it is challenging to accurately align tasks with ICTs and increase individuals' perceived task-technology fitness [58].

Table 1. Determinants to Adopt and Use ICTs in Emergency Management Phases

Determinant	Description	All	Mitigation	Prepare	Response	Recovery
Individual						
Performance Expectancy	Perceived usefulness of ICTs to support individual tasks and group performance of disaster response, influenced by perceived information quality	[2, 36, 39, 40]			[13, 15, 17, 33, 34, 43, 48]	
Effort Expectancy	Perceived ease of use for emergency management, associated with perceived task-technology fitness, and information overload	[2, 36, 39, 40, 53, 60]			[1, 3, 4, 15, 33, 34, 43, 48, 52, 62]	
Knowledge and Skills	Staff's capability to utilize ICTs for operations in emergency management	[5, 6, 31]	[7, 21]	[41]	[17, 28, 32, 43, 47, 52, 58]	
Organizational						
Government Strategies	Government commitment and planning to support emergency management and provide budget, structure, actors, and digital tools in emergency management	[6, 44]	[21, 37]	[50]	[16, 26, 32, 43, 47, 52, 56, 61]	
Leadership	Key individuals with decision-making power at the top-level of government organizations who are responsible for emergency management	[40, 44]		[50]	[16, 26, 61]	
Financial Resources	Availability of organizational budget to use ICTs for emergency management	[5, 31, 44]	[37]	[41, 50]	[3, 17, 25, 26, 51]	
Culture	The values, belief, and norms in organizations about emergency management in general and about ICTs	[12, 40]		[42]	[17, 25, 55, 57, 58]	
Inter-organizational Collaboration	Multiple organizations coordinating to design and implement management measures for disasters	[44]		[41, 42, 50]	[9, 16, 23, 27, 33, 55, 58]	
Contextual						
Legal framework	Legal framework such as laws and decrees governing emergency management and governing ICTs	[6, 8]			[3, 4, 26, 28, 43, 51, 52]	
Social Influence	Degree to which an emergency management official believes that others think he or she should use ICTs for emergency management	[40]			[33, 48]	
Tech Infrastructure	National or regional fundamental infrastructure that support connectivity and link among individuals and organizations	[6]	[37]		[13, 23, 28]	
Social and Cultural Environment	Social and demographic situation of a country including population, income, education, digital literacy	[6]			[25, 26, 30, 33, 45]	

Perceived information overload seems one of the major barriers to utilize ICTs for disaster response. Information overload refers to situation where information floods into organizations at a rate too fast for them to process [28]. While some participatory ICTs, such as social media or VGI, are perceived as useful real-time information sources, staff may not have sufficient capability to effectively organize the information and make decisions based on its priority and relevance [45, 49]. The effort expectancy to overcome information overload is perceived too high by some emergency managers to use participatory ICTs [50].

3.1.3. Individual knowledge and skills. Individual knowledge and skills generally refer to staff's capability to utilize ICTs, to manage information, and to conduct data analysis that support emergency management [6, 30]. Staff's spatial thinking are both important to utilize GIS for mitigating risks of disasters [7, 20]. Lu et al. [39] suggest that, in disaster preparedness, staff with technical expertise and data literacy is important to utilize social media data to identify potential hazards and to develop an accurate understanding of the vulnerability. Other scholars show that communication skills to informally interact with citizens become an important determinant to effectively use social media for disaster response [50, 54]. In addition, personnel's communication skills are also important to enable the effective use of collaborative data analytics for knowledge and expertise sharing in the disaster response [56]. Due to rapid advancement in ICTs, training becomes critical to help staff acquire skills for effective use of ICTs in emergency response [39, 50].

3.2. Organizational determinants

Organizational determinants refer to how an organization operates, its structure, norms, practices, rules, and culture. Studies find that government strategies, organizational leadership, financial resources, organizational culture, and inter-organizational collaboration influence the adoption and use of ICTs in emergency management [42, 48].

3.2.1. Government strategies. Government emergency management strategies generally refer to the commitment and planning to support emergency management and strategic support about budget, structure, actors, and digital tools in emergency management field [6]. Lack of priority for disaster mitigation and preparedness in its emergency management strategies becomes one of the barriers to adopt ICTs for hazards recognition, identification of vulnerable areas, risk assessment, and anticipating disaster [20, 35]. Clear strategic plans about mobile ICTs help agencies to clarify the roles of new ICTs during emergency response and ensure necessary resources for effective use of mobile ICTs [16, 42].

However, lack of clear policies and guidelines hinders organizations from using social media for emergency response [31, 41, 59]. Current guidelines or policies in police, fire or other emergency management agencies may not allow systematic adoption and use of social media integrated with the emergency response system [25, 41, 54]. They emphasize information accuracy, centralization, and personnel abstain from usage of social media tools during work. It is recommended to create a government-wide strategy to address user behavior and information confidentiality for effective use of social media during response [31].

3.2.2. Organizational leadership. Studies argue that a strong leadership is critical to adopt and use ICTs in emergency management [38, 42]. Lindsay et al. [38] have examined two types of leadership and found that both local leadership supervision and top-management buy-in are important factors. They argue that organizational leadership needs to "sell" rather than "force" adoption of new ICTs to the rest of the organizations [38]. However, FathiZahraei et al. [20] argue that a top-down leadership style is needed to provide a strong pressure forcing GIS use, especially at mitigation and preparedness stages [48]. For emergency response, scholars find strong evidence that executive leadership, who creates strategic teams, formulates policies, steers the process of organizational transformation, allocates resources, and supports second-order organizational learning, drive adoption and use of ICTs [16, 59]. While mid-level managers demonstrate the utility of ICTs to others, high-level leaders can develop policies that allow others within health, fire, and police departments to engage [41].

3.2.3. Financial resources. Lack of sufficient funding is often regarded as a major barrier to effectively adopt and use ICTs for emergency mitigation, preparedness and response [5, 30, 39]. Studies show that financial resources are needed to cover cost for the purchase, setup, maintenance, upgrade, and training required to adopt an ICT for emergency preparedness and planning [48]. However, organizations have challenges to justify spending limited budgets on ICTs specifically enhancing emergency mitigation and preparation when basic needs have priority [30, 39]. Investment in ICTs for emergency preparedness should be considered as a part of overarching ICT planning that balances the needs for routine operation and emergency management. In developing countries, where disasters may cause more devastating damage, financial resources are replied on the flow of international financial aid instead of their

own budget, which may not sustain ICT use to support disaster mitigation in the long-term [35]. For emergency response, studies also emphasize the importance of sufficient funding to support sustainable use of ICTs in the long term, especially for mobile technologies [3, 42], Computer-Aided Dispatch system [49], crowdsourcing platforms [25], and cloud-based technologies [39].

3.2.4. Organizational culture. Organizational culture refers to the values, beliefs, and norms in government about emergency management in general and about ICTs in particular [55, 56]. Scholars argue that a better understanding of response cultures is required for successful integration of GIS into emergency management efforts [12]. For emergency preparedness, professional culture influences emergency managers' perceptions of their own professional roles and their vision of the applicability of ICTs to disaster communication [40]. In a technocentric culture regarding emergency management as exchange of disaster knowledge, emergency managers are more likely to seek improvement in data processing and information distribution by adopting new ICTs. In an anthropocentric or ecocentric culture seeing emergency management as the result of inter-personal interaction, emergency managers prefer the increased levels of interaction between professionals across specialties and may have doubts about the overall ICTs' ability to transmit non-verbal information. Differences in the nature of professional cultures of police, fire rescue services and ambulance services impede the effective use of ICTs to support integration and standardization of operator intake and dispatch [53].

3.2.5. Inter-organizational collaboration. Multiple agency collaboration could enhance the development of interoperable systems and facilitate the use of new ICTs in emergency management [42]. Studies show organizations of search and rescue, first-aid, and humanitarian services are familiar with each other through collaboration during normal times and tend to work better with ICTs for effective disaster knowledge sharing for emergencies preparedness [39, 40]. For emergency response, since local governments often need to be in compliance with standards of operation employed by joint planning, they change their attitudes about ICT usefulness and alter their intention to adopt ICTs based on the expected benefits [26, 32]. In the wake of large-scale response in World Trade Center Crisis, new multiple agency collaboration has been created to overcome traditional organizational barriers and to facilitate data integration across local, state, and federal governments to utilize GIS technologies [26].

In the need of inter-organizational collaboration for emergency response, scholars emphasize that shared strategies among multiple agencies are very important for ICT adoption and use [16]. In the event of a catastrophic natural disaster that overwhelms a single jurisdiction, decision makers from the adjacent local governments need to develop a shared vision for effective RFID deployment and to further share economic and non-economic resources across the jurisdictions [16]. In addition, understanding not only organizations' own culture, but also cultures of other actors in the emergency response is important to adopt ICTs for multiple agency cooperation [10].

3.3. Contextual determinants

Contextual determinants refer to the environment that organizations are embedded in, including political, economic, social, demographic, and technological determinants. The results show that ICT adoption and use in emergency management is influenced by the legal framework, social influence, IT infrastructure, and macro social and cultural environment.

3.3.1. Legal framework. The possible legal issues is regarded as a common concern for emergency management agencies to adopt and use new ICTs [6]. Emergency response often involves legal challenges of handling of personal information, illicit uses of private data, or the unauthorized disclosure of data to third parties [25]. Lack of a clear legal framework that defines liability for the misinformation on social media may deter emergency management agencies from utilizing those new ICTs for response [28, 41]. The legal restriction regarding privacy and security also obstructs the adoption of social media to disseminate and exchange information with citizens in disaster response [4, 50]. Laws on personal data protection may strictly prohibit identity information from being used without the explicit consent of those concerned, which could limit the use of social media for greater public good during crisis response [3, 48].

3.3.2 Social influence. Social influence, in general, refers to the degree to which an emergency management official believes that others (e.g. citizens, colleagues or peer agencies) think he or she should use ICTs for emergency management [32, 57]. Operational officers in policing department, seeing their peers using mobile technologies, are driven by the peer pressure to use the same technologies so that they are not lagged behind and diminish their image to local constituents [38]. As local emergency management agencies often work with regional and state officials for disaster that exceed their capabilities, local officials' decision to adopt ICTs are influenced by social pressure embedded with regional

and state partners as well as other agencies that local emergency managers believe are important [32].

3.3.3. Technological infrastructure. Scholars argue that technological infrastructure is an important barrier to use ICTs for emergency management in developing countries or rural areas [13, 22, 35]. The following aspects are regarded especially critical to support ICT adoption and use in emergency management: communication infrastructure (terrestrial, radio, and satellite), information infrastructure (hardware and software, disaster data services), Internet penetration (quality, affordability), and system interoperability [6]. Kim et al. [35] find that the technological infrastructure is not ready in the developing countries, even though inexpensive ICTs (e.g. GIS and RS) are ready for transfer for disaster reduction. In rural areas, a difficult terrain with mountains, valleys, and other physical obstacles impedes the use of traditional ways to provide stable Internet connection [22].

3.3.4. Macro social and cultural environment. Social and cultural environment generally refers to social and demographic contexts of a country or region, including population, income, education, digital literacy, and awareness toward emergency management [6]. Local municipalities with larger population often utilize social media to disseminate information to a wide range of audience, facing the large demands of online communication about crisis information in a short-period of time [24, 43]. Some scholars argue that a jurisdiction with a higher disaster vulnerability would be more likely to adopt ICTs since they face greater risks to major disasters and their local officials are likely to take pro-active actions to minimize the impact of hazards [35]. However, Jennings et al. [32] find that emergency managers in the most vulnerable communities may also be the most strapped for funds and technological expertise to acquire EMDSS.

The digital divide is one of the major barriers to the effective use of social media or crowdsourcing in emergency response. It refers to those populations who do not have access to the Internet services, primarily in least developed countries but also present amongst marginalized populations in developed countries [25]. This digital divide is not only related to demographics or socioeconomic status but also people's deliberate choice to remain "technologically illiterate". On the one hand, digital divide is a pressing issue for emergency managers in rural communities or with an older population to effectively disseminate information since these people are less likely to engage online [25]. On the other hand, emergency managers may have challenges using crowdsourced data to make correct decisions and allocate resources properly to the affected population who need them most, since they are often the groups not adequately included in the datasets [28]. Using information from VGI that often represents the elite over the marginalized groups, emergency managers may risk further marginalizing these groups while unequally benefiting others [27].

4. Discussion

This study conducted a literature review to identify the main determinants of ICT adoption and use in emergency management. Not surprisingly, results in Table 1 indicate that the adoption and use of ICTs in emergency management is not merely a technological issue, but needs to be understood as a socio-technical phenomenon that involves the interaction among multiple social actors and between social actors and ICTs [23]. Further, the adoption and use of ICTs in emergency management is influenced by different determinants at the individual, organizational, and contextual levels. This aligns with scholars' perceptions that a comprehensive picture of ICT adoption and use requires further understanding about the effects of multi-level determinants in the different phases of emergency management [6, 42, 48].

This review also helps to identify research gaps in the literature and to propose a research agenda that further enhances our understanding of key determinants. First, most current studies focus on ICT adoption and use for the response phase, while few of them on ICTs in mitigation and preparedness. There are no studies in this sample of literature that specifically address ICT adoption and use in the recovery phase. While ICTs are also adopted and used in other phases, scholars seem to pay more attention to ICTs in emergency response because in this phase the role of ICTs seems to be more visible than in other phases [48]. In other phases, ICTs also play important roles in sharing information for citizen alert, collecting data for hazard analysis, and/or sharing knowledge for effective disaster mitigation and preparation [39, 48]. Especially in recovery phase, the adoption and use of ICTs could further help accurately access the loss for the affected community to return to its pre-disaster state and to address potential future risks to make it less vulnerable. A better understanding of determinants of adoption and use in all phase is critical to make better use of ICTs for stronger emergency management capacity. Future research could pay more attention to other phases to better understand and compare determinants of ICT adoption and use in different emergency management phases.

Second, for individual determinants, current literature indicates both perceived information quality and task-technology fitness are especially important in the field of emergency management [11, 25, 41].

However, given that the domain of emergency management has to deal with unpredictable situations, it is still not clear how to evaluate information quality in real-time or to make accurate alignment between tasks and ICTs. A standard for information quality that is too high may limit the adoption of useful social media data for quick response, while a low standard for information quality may include false information that lead to incorrect response actions [54]. A better understanding about information quality in disasters can help to make better decisions to adopt and use appropriate ICTs (e.g. social media) under certain circumstances, as input to certain decisions, and as valuable at certain times. Research could further develop metrics, methods, and frameworks to operationalize perceived information quality and task-technology fitness and validate them through empirical studies that further guide ICT adoption and use in emergency management.

Third, for organizational determinants, current studies suggest that collaboration between professional emergency management agencies is critical to ICT adoption and use in emergency response, especially in the wake of large-scale disasters [32, 39, 40]. However, scholars have not fully examined the influence of collaboration between non-professional and professional actors in emergency management. As non-professional citizens or community groups start being recognized as important actors in the emergency management [11, 25], emergency management agencies begin to adopt new ICTs (e.g. crowdsourcing platforms or social media) to incorporate their contributions in the emergency response. This new type of collaboration represents a new approach of information sharing unfamiliar to emergency responders. It requires more in-depth knowledge of the language, culture, and presentation of information from non-professionals so that professionals can effectively adopt and use new ICTs. Future research could pay more attention to the nature of different types of collaboration among various individual and organizational actors in emergency management on ICT adoption and use. As multi-actor collaboration often relates to social networks, the unit of analysis could also turn to systems and networks rather than single individuals or organizations.

Fourth, for contextual determinants, current studies find some specific determinants such as lack of technological infrastructure [35] or the digital divide [27], which are often associated with poor communities and rural areas. However, studies specifically addressing ICT adoption and use in rural areas for emergency management are still very limited. Scholars have not taken into account other interrelated aspects in the rural areas, such as geographic characteristics, funding structure, types of emergency response workforce, and societal culture and norms [44]. Those unique features in rural areas may fundamentally change the model of emergency management and thus the adoption and use of ICTs. A difficult terrain with physical obstacles not only limits Internet connections but also changes the needs of communication and resources during emergency response. A self-reliance community culture, skepticism about ICTs, and voluntary response workforce also may affect how emergency management agencies adopt and use ICTs. A better understanding of those unique features of rural areas can help to make appropriate decisions on ICTs for emergency management. Future research needs to take specific contexts into account and to better understand ICT adoption and use for emergency management in rural areas.

5. Conclusion

Based on a comprehensive review of current literature on the determinants that influence ICT adoption and use in emergency management, this paper proposes a research agenda for the future. The review has identified multiple determinants at the individual, organizational, and contextual levels that affect ICT adoption and use in emergency mitigation, preparedness, and response. A research agenda with four potential research topics is proposed for future studies.

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