Fighting an Infodemic: Managing Virtual Communities during Times of Disaster

By

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ABSTRACT

Natural disasters pose a significant societal challenge and impact our society at large. People now extensively use social media to create or appropriate existing virtual communities during a disaster. Virtual communities can provide useful information and help victims cope with disaster impacts. However, these self-same virtual communities can worsen a disaster victim's situation because they can be used to spread falsehoods and irrelevant information, leading to an infodemic (i.e., an overabundance of accurate and inaccurate information). Furthermore, existing practices or policies for managing the community and disseminating information can easily become obsolete during a disaster. This thesis develops a better understating of how virtual communities can be managed to generate and disseminate trusted information when and where it is needed during disasters. Two natural disasters, Hurricane Harvey in 2017 and, The Great Texas Freeze Out 2021, were studied to better understand this subject. Using an interpretive case study approach, digital trace data from a Reddit disaster community were collected and analysed. The research findings are presented as three inter-linked papers. The first paper explores how to foster a sense of community that can help generate trusted information; the second paper explores how to disseminate trusted hyperlocal information, and the third paper explores how and why diversity hinders the spread of trusted information. Collectively, this thesis contributes to a relevant yet relatively underexplored area of research in Information Systems (IS). The thesis makes suggestions for how virtual community leaders, emergency authorities, and system designers can use a virtual community during a disaster.

This thesis is dedicated to my parents and my loving wife Sonia

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LIST OF ORIGINAL ARTICLES

This thesis consists of an introduction and conclusion and three original papers. The original papers are listed below, along with a description of the author's contribution.

Paper I

Hasan, M., Chua, C. E. H., & Myers, M. (2022). Together We Survive: Constructing a Sense of Community in Virtual Communities during Times of Disaster.

A poster version was presented at the Information Systems for Crisis Response and Management (ISCRAM) Asia Pacific 2018 in Wellington, New Zealand.

A fuller (but still abridged) version of this article was published at PACIS 2021 in Dubai, UAE. See *Proceedings of the Pacific Asia Conference on Information Systems (PACIS). 53.* *https://aisel.aisnet.org/pacis2021/53*

The full version included in the thesis will be submitted to a journal.

As first author, Mahmudul Hasan has taken the lead in writing this article with editing done by the co-authors.

Paper II

Hasan, M., Chua, C. E. H., & Myers, M. (2022). From Chaos to Clarity: How can Virtual Communities Provide Trusted Hyperlocal Information during a Disaster. We received a *revise and resubmit decision from Information Systems Journal.*

The paper has attracted positive reviews. An earlier version of this paper received major revisions at *Management Information Systems Quarterly (MISQ).*

As first author, Mahmudul Hasan has taken the lead in writing this article with editing done by the co-authors.

Paper III

Hasan, M., Chua, C. E. H., & Myers, M. (2022). How and why does diversity in a virtual community hinder the dissemination of verifiable, accurate and reliable disaster information? *Submitted to Information Systems Research. Special issue- Unleashing the Power of Information Technology for Strategic Management of Disasters.*

This paper is currently under review as of March 20, 2022 at *Information Systems Research*. As first author, Mahmudul Hasan has taken the lead in writing this article with editing done by the co-authors.

GLOSSARY OF KEY TERMS

This thesis contains certain key terms which will be used consistently throughout the thesis. The following provides a glossary of what each term means.

Trusted information: Trusted information refers to the information that is verifiable, reliable and accurate (VAR). Throughout the thesis, the words "trusted" and "VAR" will be used interchangeably.

Hyperlocal information: Hyperlocal information refers to the information specific to a narrow geographic locale (e.g., a particular affected street), rather than nonspecific information pertinent to the entire disaster-affected area.

Infodemic: Infodemic refers to an overabundance of information including accurate and false or contradictory information, inhibiting individual's ability to find trusted information and reliable guidance when they need it.

Digital trace data (DTD): Digitally recorded and time-stamped logs of activities and events stemming from human interaction with digital technology (e.g., social media).

Reddit: Reddit is a social news aggregation, web content rating, and discussion platform of self-governed virtual communities.

Subreddit: Self-created communities of users (i.e., sub-communities) on Reddit platform, united by a certain topic.

Institution: Institutions are widely diffused practices, technologies, rules, or organizational forms that enable and regulate social actors' behavior and make social life predictable.

Houstonian: Individuals who lived in Houston identified as Houstonian.

CHAPTER 1. INTRODUCTION

1.1 Research Background

In recent years our contemporary social, political, and economic life has been increasingly influenced by digital technologies such as social media and the Internet. Some commonly used social media tools include discussion forums, wikis, social networking sites (e.g., Facebook, Twitter, Instagram), and social news aggregation sites (e.g., Reddit, Digg). People use social media to create virtual communities to exchange information, ideas, opinions, and personal messages. Ironically, along with technological advancement, disasters are also increasing in frequency and severity (Ogie et al., 2022; Tim, Pan, Ractham, & Kaewkitipong, 2017). As the author writes this thesis, the world is experiencing a global COVID-19 pandemic.

1.1.1 Disasters

A disaster can be defined as a potentially traumatic, unexpected event that is collectively experienced (McFarlane & Norris, 2006). A disaster inherently creates uncertainty, chaos, and panic. It disrupts and threatens the normal conditions of a community. While people are prone to different kinds of disasters, natural disasters (e.g., hurricanes, earthquakes, and disease outbreaks) appear to be increasing in frequency and intensity around the world (Ogie et al., 2022). Emergency situations arising from natural disasters cause significant social, economic, and environmental loss. Natural disasters can be short-lived (e.g., a hurricane) or prolonged (e.g., epidemic disease). While short-lived disasters occur suddenly and require immediate response, the impact of prolonged disasters is spread over a period of time. This thesis focuses on short-lived natural disasters. Although preventing a natural disaster from happening might not be possible, its risks can be minimized by enhancing the capacity of affected communities to respond (Ahmed, 2011).

Disaster sociologists suggest natural disasters are typically managed through four phases: *mitigation, preparation, response, and recovery* (Sun, Bocchini, & Davison, 2020). Mitigation and preparation phases happen before a disaster. The response phase happens during a disaster, and the recovery phase follows after the disaster ends. Each phase involves different activities and poses certain challenges. Effective strategies for each phase are required for efficient disaster management.

This thesis focuses on the response phase of a disaster. Although all four phases are equally necessary, the response phase is the most significant because it addresses the immediate threats presented by a disaster (Altay & Green, 2006). Activities such as disseminating information, issuing warnings, assessing damages, distributing resources, and search-rescue operations fall under the response phase. In recent times, social media tools have been playing a critical role in response actions following natural disasters (Nan & Lu, 2014; Stieglitz et al., 2022; Tim et al., 2017). During disasters, people often turn to social media to create or appropriate existing virtual communities to seek or provide information.

1.1.2 Characteristics of Disaster-Oriented Virtual Communities

A virtual community is "a group of people who communicate and interact, develop relationships, and collectively and individually seek to attain some goals in an IT-supported virtual space" (Meng & Agarwal, 2007). Virtual communities are built on open membership and typically support anonymous participation (Faraj, von Krogh, Monteiro, & Lakhani, 2016; Fatima et al., 2019; Lu & Yang, 2011). Hence, community members are not geographically or physically bounded (Faraj et al., 2016). Diverse individuals can come together in virtual communities to share a common interest and express diverse opinions. Research suggests diversity increases creativity in solving problems by encouraging broader perspectives and alternative solutions (Endres & Chowdhury, 2013; Hong, Ye, Du, Wang, & Fan, 2020).

However, unlike physical communities, virtual communities have weaker social forces to keep members in a community (Faraj, Jarvenpaa, & Majchrzak, 2011; Kim, Kim, & Kim, 2020). Research suggests a sense of community (SoC) (i.e., the feeling of belonging and being attached to a community) can act as a social glue that binds diverse individuals together in virtual communities (Lyu, Wang, Ma, Wang, & Zhao, 2019). Furthermore, SoC is a psychological property of a community that help generate trusted information (Kim et al., 2020; Paton & Irons, 2016). People visit virtual communities for different purposes such as information acquisition, seeking belonging, crowdsourcing, business, and marketing. Virtual communities use message boards, discussion forums, and chat rooms (Rutherford, Hoeninger Jr, & Wiest, 2012).

In a non-disaster situation, the typical virtual community has individuals with diverse needs and interests, and it is important to support a large subset of those needs for the virtual community to thrive. However, during disasters, their needs and interests narrow significantly- most individuals demand a lot of hyperlocal information (i.e., information specific to a narrow geographic locale), need rescue, basic necessities, and emotional support (Nan & Lu, 2014; Qu, Wu, & Wang, 2009; Tim et al., 2017). Moreover, they need trusted (i.e., verifiable, accurate, and reliable) information in a timely manner to cope with the disaster (Lu & Yang, 2011; Oh, Agrawal, & Rao, 2013). Virtual communities act as information providers and support recovery during many disasters. For example, during Hurricane Sandy, users shared real-time images on Instagram with the hashtag #Sandy to indicate their locations and describe their situations (Schifferes et al., 2014). When tornado Joplin hit Missouri in 2011, people sought real-time information about the shelter, food, medical and other needs from virtual communities (Fraustino, Liu, & Jin, 2018).

1.1.3 The Rise of an Infodemic

Although virtual communities serve as a valuable source of useful disaster information, they are not a panacea. They can also amplify chaos and increase uncertainty during disasters. One significant impact of natural disasters is the rise of an *'infodemic'* in virtual communities. Infodemic refers to an overabundance of information, including accurate and false or contradictory information, inhibiting individuals' ability to find trusted information and reliable guidance when needed (Scheufele, Hoffman, Neeley, & Reid, 2021; Stieglitz et al., 2022). Due to the urgency of disaster response, victims often struggle to differentiate between reliable and unreliable information. Infodemic causes confusion and leads to risk-taking behaviours, which can put disaster victims at increased risk (Haas, 2021; Rai, 2020). For example, during Hurricane Sandy in 2012, screenshots from the movie *The Day After Tomorrow* and other dramatic pictures from past storms proliferated on virtual communities. Additionally, there is growing evidence that virtual communities suffer from the presence of uncivil behaviours (e.g., trolling, name-calling, spamming, rumour-mongering) (Luna & Pennock, 2018; Wise, Hamman, & Thorson, 2006). When community participants enact uncivil behaviours, they contribute to the infodemic by generating irrelevant information. Uncivil behaviours also impact public perception of the virtual community and encourage people to withdraw.

1.2 Motivation and Research Questions

> *"We focused only on the positive implications of social media in enabling disaster response. Addressing the potential drawbacks and unintended consequences of social media is beyond the scope of the paper, but would be an important next step for future research"* – Tim et al., (2017)

Virtual communities have been in existence for over thirty years. The rapid growth of virtual communities has been well documented in the literature. Information Systems (IS) researchers have studied virtual communities, and these studies yielded powerful insights into

marketing, social relationships, learning, benefits of participation, and more (Dissanayeke et al., 2021; Faraj et al., 2011; Wu & Bernardi, 2020). Disaster information management is an emerging area of inquiry for IS researchers. This area focuses on the social, technical and practical aspects of IS in all the phases of a disaster. Many top IS journals are creating special issues on disaster information management, for example, Information Systems Research (ISR) in 2021. Yet, compared with other disciplines, scholars in IS have been relatively silent about disaster management. Several calls for research have emerged in recent years to encourage IS scholars to explore issues (e.g., misinformation) related to disaster information management (e.g., Abbasi, Dillon-Merrill, Rao, Sheng, & Chen, 2021; Spanaki et al., 2021).

During a disaster, people need trusted information, and their needs and interests also become hyperlocal. However, many authoritative sources (e.g., emergency authorities) often provide generic information (e.g., go to your nearest shelter, request rescue by calling 911) that do not fit the local context. Therefore, people to need to transform authoritative information into hyperlocal context. However, most virtual communities are not designed to be hyperlocal or help with disaster management (Nan & Lu, 2014; Qu et al., 2009; Tim et al., 2017). Besides, the rise of an infodemic, including uncivil behaviours in virtual communities, makes it challenging for people to find trusted information they can act upon.

Some studies suggest to support a leadership structure that can help manage the community by moderating contents, cultivating norms, organizing activities, and leading discussions (Chu, 2009; Chua, 2009; Ivaturi & Chua, 2019). However, existing practices or policies for managing the community and disseminating information could easily lose relevance when new, unprecedented requirements arise as the disaster unfolds (Majchrzak, Jarvenpaa, & Hollingshead, 2007; Tim et al., 2017). Researchers have argued that work on

disaster-oriented virtual communities is still underdeveloped (Leong, Pan, Ractham, & Kaewkitipong, 2015; Nan & Lu, 2014; Reuter, Hughes, & Kaufhold, 2018; Tim et al., 2017).

Taken together, prior IS research highlights the importance of virtual communities during disasters and primarily focuses on the positive implications (e.g., Nan & Lu, 2014; Tim et al., 2017). However, how to combat an infodemic, transform authoritative information into hyperlocal context and improve the spread of trusted information during disasters is still remained underexplored in IS research. This thesis is set forth to contribute understanding to this phenomenon. Therefore, this thesis aims *to develop a better understating of how virtual communities can be managed effectively to generate and disseminate trusted information during disasters*.

To achieve this aim, three studies were conducted and the author wrote three original papers. During disasters, people need trusted information in general and hyperlocal information in particular. Paper I explored how to construct a sense of community that can help generate trusted information; Paper II, investigated how to transform authoritative information into hyperlocal context and disseminate it. Paper III examined how and why diversity hinders the dissemination of trusted information. These three inter-linked papers provide deeper insights into how virtual communities can combat an infodemic, generate and disseminate trusted information. The specific research questions addressed are as follows:

Virtual communities suffer from the problem of uncivil behaviours, which can exacerbate an infodemic and impede trusted information from flowing across the community. Moreover, the presence of uncivil behaviours can encourage people to leave the community. A good disaster-oriented virtual community is self-correcting and promotes pro-social behaviour. Research suggests a sense of community (SoC) among virtual community members is critical to fostering self-corrective and pro-social behaviour. Furthermore, SoC can help

generate trusted information. Developing SoC in virtual communities is fundamentally different than in physical communities because virtual structures are more fluid, information-driven, self-governed, and actions are more disorganized (Faraj et al., 2011; Nan & Lu, 2014). Moreover, prior research provides inconclusive results and falls short of addressing how SoC can be quickly constructed in virtual communities during a disaster. Therefore, this thesis aims at answering the following research question:

RQ1: *How can a sense of community be constructed and maintained in self-governed virtual communities during times of disaster?*

(Paper I)

During disasters, individuals of affected areas desperately need hyperlocal information to make localized decisions (Oh et al., 2013; Shklovski, Palen, & Sutton, 2008). In the past, the dissemination of disaster-related information was unidirectional (i.e., information flowed from authority to the public). However, authoritative sources, including the mainstream media, often fail to provide information at a sufficiently granular level (Ludwig, Kotthaus, Reuter, Dongen, & Pipek, 2017; Oh et al., 2013). Now, with the emergence of social media, people can create or appropriate existing virtual communities to share real-time hyperlocal information. However, the open and anonymous nature of virtual communities can also allow people to create an infodemic. Therefore, how virtual communities can simultaneously disseminate truthful, useful, hyperlocal information quickly while suppressing false, irrelevant information during a disaster is little understood. As such, this thesis seeks to address the second research question:

RQ2: *How can virtual communities provide trusted hyperlocal information during a disaster?*

(Paper II)

While addressing RQ1 and RQ2, this thesis discovered an important and unexpected finding, which encouraged formulating a new research question. A prominent feature of a typical virtual community is diversity. Prior research argues diversity is vital for solving

problems (e.g., mitigating falsehoods) in virtual communities (e.g., Chu, 2009; Divakaran & Nørskov, 2016). However, this thesis discovered just the opposite. During a disaster, diversity can hinder the provision of trusted information and fuel the infodemic. Falsehoods can spread more easily if a virtual community is diverse. However, how and why diversity in a virtual community acts in a way during disasters that research suggests it should not remain unknown. Therefore, this thesis poses the final research question as follows:

RQ3: *How and why does diversity in a virtual community hinder the dissemination of verifiable, accurate and reliable information during a disaster?*

(Paper III)

1.3 Structure of the Thesis and Research Approach

1.3.1 Structure of the Thesis

This thesis consists of three original papers. Figure 1.1 illustrates the overall thesis structure. The synopsis of this thesis is as follows:

Chapter 1 introduces the background on the problem area and presents the motivation and research questions. It also briefly outlines the research design, including the methodological approach of this thesis and the methods applied in each paper.

Chapter 2-4 presents the main findings of this thesis in the form of three separate papers. **Chapter 2** includes the first paper of this thesis. **Paper I** attempts to answer the first research question. This paper presents an in-depth interpretive case study of a virtual community, the r/Houston subreddit, looking at how this community constructed a SoC during Hurricane Harvey in 2017. The concepts of socialization, formal control and sense of community are used to analyse the data and interpret findings. The paper sheds light on how to effectively integrate the effort of moderators and community members to cultivate a SoC.

In Chapter 3, the second paper of this thesis is presented. **Paper II** answers the second research question. It explores how virtual communities can provide trusted hyperlocal information during a disaster. The risk society theory is used to analyse data and interpret findings. Based on an in-depth interpretive case study of the r/Houston subreddit, this paper reveals what institutions are required to transform authoritative information into local context and disseminate trusted hyperlocal information during a disaster.

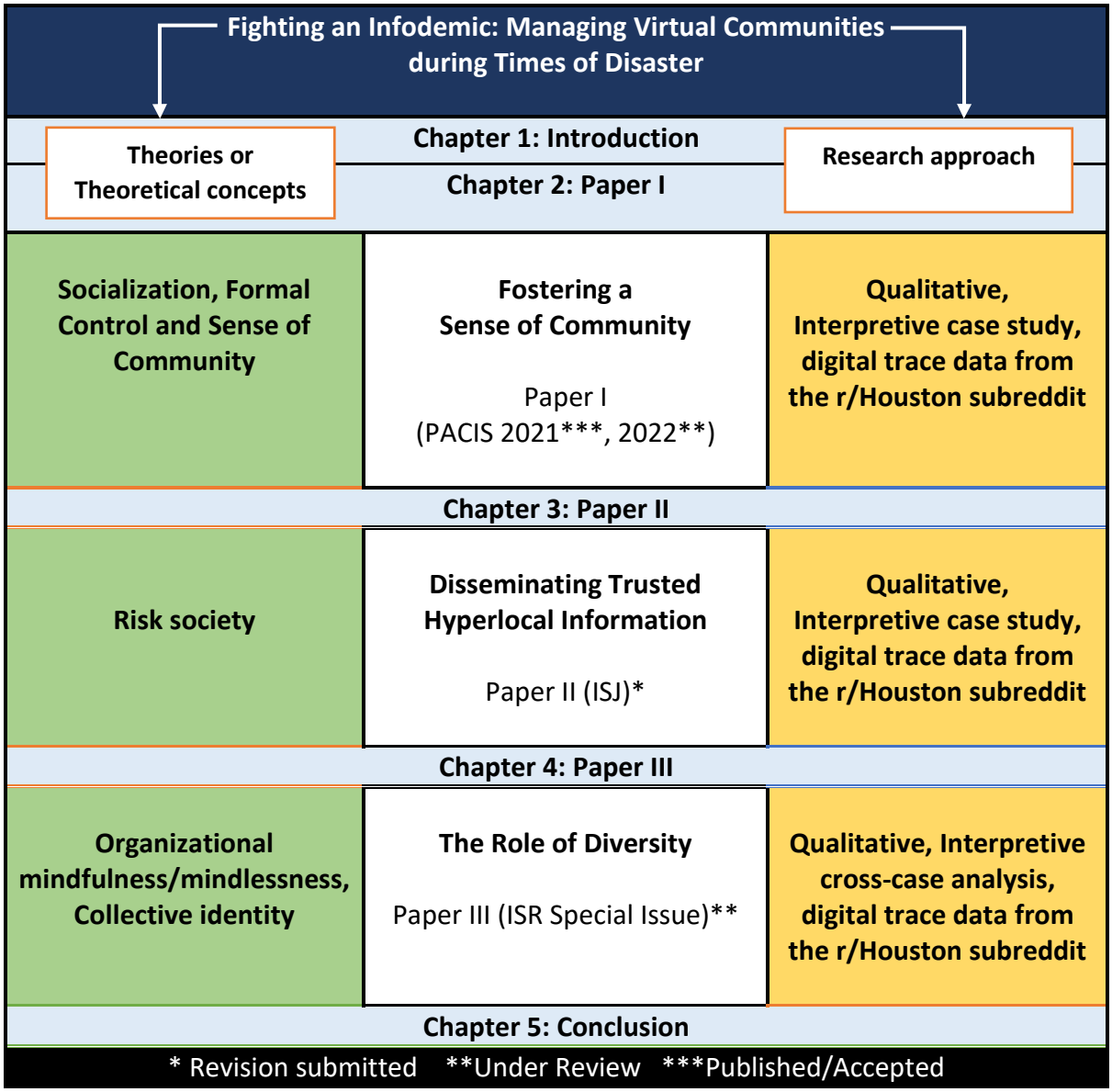

Figure 1. 1 Thesis Structure

Chapter 4 presents the third paper. **Paper III** addresses the final research question. An in-depth, exploratory cross-case analysis of the r/Houston subreddit is employed to answer the

research question. Two disaster scenarios: (1) Hurricane Harvey in 2017 and (2) the Great Texas Freeze Out in 2021 are used for the cross-case analysis. Using the lenses of organizational mindfulness/mindlessness and collective identity, the paper uncovers how and why diversity in a virtual community hinders the provision of trusted information during disasters.

Finally, **Chapter 5** concludes the thesis. It presents the summary of the contributions of each paper together with discussing limitations and some opportunities for future research.

1.3.2 Research Approach

This thesis follows Myers's (2020) model of qualitative research design. Most research on virtual community-led disaster response uses a quantitative approach combined with social network analytics (SNA) (e.g., Mirbabaie, Bunker, Stieglitz, Marx, & Ehnis, 2020; Stieglitz, Mirbabaie, & Milde, 2018). SNA techniques are typically used to visualize and identify patterns for predicting modelling. However, such predictive models, visualizations, and patterns are not theories (Berente, Seidel, & Safadi, 2019) and often fail to convey an understanding of processual phenomena (Agarwal & Dhar, 2014). As illustrated in Figure 1.1, this thesis employs a qualitative approach that offers rich insight (Myers, 2020) on virtual community roles in containing an infodemic and promoting trusted information dissemination.

In this thesis, interpretivism is taken as the underlying philosophical assumption. Interpretive studies assume that reality (given or socially constructed) is accessed only through social constructions such as a language, consciousness, shared meanings, documents, tools, and other artifacts (Klein & Myers, 1999). This approach is recommended for exploring socio-technical phenomena that are both context and time dependent (Orlikowski & Baroudi, 1991). It can help gain an in-depth understanding of a phenomenon within its contextual situations and through the participants' viewpoint (Klein & Myers, 1999; Walsham, 1995). Moreover, the interpretive approach has been applied increasingly in IS studies for disaster management

(e.g., Tim et al., 2017). Using an interpretive approach, the author uncovered deeply contextualized patterns and developed theoretical insights for emerging, underexplored phenomenon.

Paper I and **Paper II** utilise case study methodology to answer RQ1 and RQ2. This approach allows researchers to investigate a phenomenon in the environment in which it naturally occurs (Eisenhardt, 1989; Myers, 2020). Besides, this approach is appropriate for studying underexplored phenomena and obtaining in-depth insights (Myers, 2020). **Paper III** uses cross-case analysis (Miles & Huberman, 1994) to answer RQ3. While addressing RQ1 and RQ2, the author discovered the lessons learned from Hurricane Harvey appear to have been unlearned, leaving the r/Houston community ill-equipped to handle subsequent disasters. Cross-case analysis can help analyse themes across the cases to uncover similarities and differences (Eisenhardt, 1989). Taken together, the methodologies employed in this thesis is suitable for answering the "how" and "why" research question (Myers, 2020).

IS researchers have been increasingly using digital trace data (DTD) for their investigations (e.g., Berente et al., 2019). Social media are the primary source of digital trace data. DTD provides relatively precise and voluminous data on actions and events (Pentland, Recker, Wolf, & Wyner, 2020). However, the sheer volume of DTD can be problematic for qualitative researchers (Myers, 2020). Hence, Myers (2020) suggests reducing the data set to a manageable size for analysis. One way of achieving a manageable data size is to focus on the key events and text that the researcher considers useful for answering the research question(s) (Myers, 2020).

In this thesis, the author chose Reddit as the principal data source and collected digital trace data from the r/Houston subreddit. Reddit data is open and archived. Hence, others can validate the data sources because they are publicly available (Miles & Huberman, 1994). Most other disaster response studies have focused on virtual community platforms like Twitter.

However, communities in Twitter are intermingled, making it difficult to understand how a particular affected community responds to the disaster. There have been calls for future research to investigate other virtual community platforms for disaster information management (Palen & Hughes, 2018). However, the quality of DTD is a growing concern in IS research. The author followed guidelines for DTD proposed by Vial, (2019). Table 1.1 illustrates how those guidelines are adopted in this thesis.

<table>
<tr><td>1. Provide an explanation of exactly what is captured in the data</td><td rowspan="2">The author collected threads and associated comments in the two weeks before the hurricane (August 11- August 24, 2017) and during the hurricane (August 25- August 31, 2017) from the selected case site. For cross-case analysis, data were collected between February 12, 2021 and February 19, 2021.</td></tr>
<tr><td>2. Report the time at which the data is collected</td></tr>
<tr><td>3. Explicitly mention the location of the data collection</td><td>The author collected data from the r/Houston subreddit. Reddit data is publicly available and archived.</td></tr>
<tr><td>4. Describe the precise process(es) of data collection</td><td rowspan="3">The database of Reddit threads and comments from 2005 until the end of 2019 (more than 3 billion) are available on Google Big Query and PushShift (i.e., a social media data collection and archiving platform), which the author used to collect the data. The author wrote SQL queries and exported data as CSV files. Later, Leximancer was used to conduct an unstructured analysis of the collected data.</td></tr>
<tr><td>5. Report the individual(s) involved in the data collection</td></tr>
<tr><td>6. Report what instruments or artifacts used in collecting the data</td></tr>
<tr><td>7. Provide a set of reasons or goals for collecting the data. Ensure that there is a clear and well justified link between the data collected and the research question.</td><td>Each paper in this thesis justifies the reasons for choosing the r/Houston subreddit and explains how they inform the posed research questions.</td></tr>
</table>

Table 1. 1 Digital trace data quality guidelines

Data collection and analysis were done iteratively (Walsham, 1995). Following the suggestions of McKenna, Myers, & Newman, (2017), the author initially used the qualitative data analysis tool Leximancer (i.e., a specialist content analysis software) to conduct an unstructured analysis of the collected data. This process helped the author to make some sense of the data and see particular patterns, but it was inadequate to answer the posed research

questions. The author then used appropriate theories to guide the analysis. More details on characteristics of the research site, data collection and analysis procedures are reported in a method section of each paper included in this thesis.

While conducting the interpretive case study, the author adhered to a well-established set of key principles proposed by Klein & Myers (1999). Those principles not only guide researchers in conducting an interpretive study but also to evaluate them. Several other studies used those guidelines to evaluate interpretive research in IS field (e.g., Boudreau & Robey, 2005). However, Klein & Myers (1999) emphasize those principles *"are not like bureaucratic rules of conduct."* They suggested it is incumbent upon authors "*to exercise their judgement and discretion in deciding whether, how, and which of the principles should be applied and appropriated in any given research project"* (Klein & Myers 1999, p. 71). This thesis focuses on four key principles, and below is a reflection on how those four principles were applied to this thesis.

1. Hermeneutic circle: all human understanding is achieved through iterating between the parts and the whole. This principle provides philosophical grounding for interpretivism. This is also a meta-principle that underpins the other principles.	Each paper in this thesis presented some individual parts of the virtual community, technology platform, and information dissemination practices. For example, the characteristics of a livethread, megathread, flairs, voting systems and the use of specific terms such as Houstonians, mods. An analysis of these individual parts was necessary to fully understand the phenomenon understudied. For example, paper III addressed the issues with goal diversity which would not be possible without knowing the insights from paper I and II.
2. Contextualization: critical reflection of the social and historical background of the research setting, so the audience can apprehend the present situation.	Each paper in this thesis includes a detailed presentation of the case and provides context for the specific inquiry. The following section (1.4.1) also provides an overview of the case site.
3. Interaction between Researcher and Subjects: critical reflection on how the data was socially constructed	This thesis used digital trace data (i.e., archived data). Therefore, the author did not influence the community participants or thread discussions. However, the author acted as an "observer" and embedded himself in the research site for over a year, studying the hurricane, and

by the researcher and participant	keeping up to date with community activities. However, the author did not engage in conversation with the community users to avoid altering the users' discursive practices. While observing the community, the author discovered unexpected findings which led to formulating RQ3. The author critically engaged with the text to question his prior assumptions during the data analysis process. The process of critical engagement with the text is crucial in an interpretive case study (Myers, 2020).
4. Abstraction and generalisation: relating the details revealed by the data interpretation to general concepts that describe the nature of human understanding and social action.	The author used multiple theories or theoretical concepts which acted as an up-front guide or sensitizing device (Myers, 2020) to inform the research project. In line with interpretive case studies, theoretical perspectives used in this thesis evolved over time. For example, in paper II, initially, the author used structuration theory to make sense of the data, but subsequently, the author found that the theory of risk society provided richer insights. Hence, the author finally settled on the risk society theory. This thesis also linked findings to existing theories, developed rich insights and generalized case findings to theory.

Table 1. 2 Principles for Conducting Interpretive Case Study (Klein & Myers 1999) and their Application throughout this Thesis

The below section provides an overview of the research site to set the stage for the subsequent sections.

1.3.3 Characteristics of the case site

The r/Houston subreddit was formed in June, 2008 and comprises individuals from diverse backgrounds with some interest in Houston. Most users live in Houston, but a sizable minority comprise individuals not living in Houston, but with an attachment to the area. For example, many participants have relatives or friends in Houston or were born in Houston. As of August 2017, when Hurricane Harvey hit Houston, the community had 62000+ members. Since, r/Houston is a large community with a diverse member pool, the majority do not know each other and have weak social ties. However, virtual communities with weak social ties are more likely to introduce more useful information and propagate new ideas (Guan, Wang, Jin, & Song, 2018; Mou & Lin, 2017).

Many participants only visited the community during the two disaster scenarios (i.e., Hurricane Harvey 2017 and The Great Texas Freeze Out 2021) investigated in this thesis. For example, during the hurricane, the r/Houston community started discussing disaster related issues. Many people (both from Houston and outside of Houston) sought information from this community. The community soon became overwhelmed with requests, as illustrated by the comment of a moderator.

"We've gone from ~90k page views per day to 3.5million over the course of the hurricane. We've been getting more threads in an hour than we would in a day."

Unfortunately, this dramatic increase in the number of users and threads also led to the emergence of risky behaviours such as the spreading falsehoods. There was a pressing need to handle these emergent risks so that people's safety would not be compromised by this kind of malicious use of the r/Houston subreddit. At the end, the community successfully mitigated these emergent risks and disseminated trusted information. Paper I and paper II report the findings and insights derived from the Hurricane Harvey case.

In recent times, the r/Houston community has experienced several other disasters (e.g., the Great Texas Freeze Out and COVID-19). However, the lessons learned from the hurricane appear to have been unlearned, leaving the community ill-equipped to handle these subsequent disasters. For example, falsehoods propagated more easily, and the community failed to disseminate trusted information. The author found the case interesting and further investigated to understand the key obstacles in virtual community-led effective disaster response within the same virtual community. Paper III reports the findings and insights derived from the cross-case analysis.

In the subsequent chapters of this thesis, the three papers are presented. The final chapter is the conclusion.

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CHAPTER 2. CONSTRUCTING A SENSE OF COMMUNITY

Abstract

During disasters, people need verifiable, accurate, and reliable (VAR) information to reduce uncertainty. Many disaster incidents have been documented where people visit virtual communities to exchange information. One way of promoting VAR information is cultivating a sense of community (SoC), i.e., the feeling of belonging and being attached to a community. While substantial research has established the beneficial effects of SoC, little is known of how SoC can be quickly constructed in virtual communities during a disaster. We conducted a qualitative case study of a virtual community and its response to a disaster. Our findings indicate that socialization and formal control can work together to foster a SoC during disasters. Prior IS research argues that isolating users and sanctioning uncivil behavior can erode an individual's SoC in virtual communities. However, we discovered that when the formal controllers (i.e., moderators) impose emergent group norms, sanction uncivil behavior and isolate problematic users, they improve SoC at the group level, especially when isolated users enact uncivil behavior.

2.1 Introduction

Natural disasters are increasing in frequency and intensity around the globe. In the last decade (2011–2020), natural disasters have affected 1.6 billion people globally, killing 188,583 people and causing over $1.7 trillion in damage costs (Ogie et al., 2022). Natural disasters are sudden events that affect victims and society at large. Moreover, they create uncertainty, mass panic and stress in daily life. When disaster strikes, people start seeking information from different sources. Many disaster incidents have been documented where people turn to virtual communities for information (Jurgens & Helsloot, 2018; Nan & Lu, 2014; Van Wyk & Starbird, 2020). People need verified, accurate and reliable (VAR) information to reduce uncertainty about the disaster. However, virtual communities are not a panacea and can also

amplify chaos and increase uncertainty (Luna & Pennock, 2018; Oh, Agrawal, & Rao, 2013). Information overload and uncivil behaviours (e.g., trolling, posting insensitive comments, rumour mongering, spamming) have been documented in disaster virtual communities. For example, during Hurricane Ida, there was a rumour that the Federal Emergency Management Agency (FEMA) was paying for evacuees' hotel rooms (Breslin, 2021). More recently, false information on covid-19 has been circulated online, such as wearing a mask actually activates the coronavirus. A good disaster-oriented virtual community is self-correcting, where some community members intervene to correct falsehoods, promote pro-social behavior and reduce uncertainty (Oh et al., 2013; Palen & Hughes, 2018; Qu, Wu, & Wang, 2009). It has been demonstrated that a Sense of Community (SoC) among virtual community members is critical to fostering self-corrective and pro-social behavior (Heverin and Zach 2012; Shklovski et al. 2008; Tim et al. 2017; Silver and Matthews 2017) thereby allowing virtual communities to weather disasters and attain community goals (Houston, Spialek, First, Stevens, & First, 2017; Norris, Stevens, Pfefferbaum, Wyche, & Pfefferbaum, 2008).

SoC is the feeling of belonging, being attached to a community and having shared faith in members' mutual commitment to fulfil their needs (McMillan & Chavis, 1986). SoC is a recognized critical dimension of resilient communities that enhances communities' capacity to respond quickly and recover from a disaster event (Norris et al., 2008). As the disaster unfolds, communities' active participation (e.g., sharing local information, correcting falsehoods) is required to generate VAR information and reduce the impact of disasters (Qu et al., 2009; Tim et al., 2017). If SoC is absent, people become isolated and detached from community issues (Blanchard & Markus, 2004; McMillan & Chavis, 1986), potentially delaying recovery efforts. Developing SoC in virtual communities is fundamentally different from physical communities because virtual structures are more fluid, information-driven, self-governed, and actions are more disorganized (Faraj, Jarvenpaa, & Majchrzak, 2011; Nan & Lu, 2014). Thus, it becomes

salient to explore how a virtual community can construct and maintain SoC in times of disaster. Our paper addresses this question: ***How can a sense of community be constructed and maintained in self-governed virtual communities during times of disaster?***

To answer this research question, we performed an in-depth case study of a virtual community on Reddit (i.e., r/Houston subreddit) that focused on disaster response during Hurricane Harvey, 2017. Our findings indicate two factors: *(1) socialization* and *(2) formal control*, which reinforce each other and, together foster a SoC. Socialization is a bottom-up approach by which community members form emergent group norms. On the other hand, formal control is a top-down approach by which moderators regulate the community. We argue that moderators need to impose emergent group norms, isolate problematic users, and sanction uncivil behaviours, which, in turn, improves SoC at the group level. We theorize how two processes we name *endorsing* and *disciplining* serve to effectively integrate the effort of moderators and community members to cultivate a SoC. Community members can inform moderators how emergent group norms work, transfer community feedback and introduce emergent leadership through the endorsing process. Concurrently, moderators can impose emergent group norms, sanction uncivil behavior and authorize emergent leaders through the disciplining process. We find that emergent leaders act as a conduit between community members and moderators.

This paper is structured as follows: first, we review the related literature on virtual communities during disasters and sense of community. Next, we present our research methodology detailing data collection and analysis procedure. This is followed by a discussion of our findings. The final section presents the discussion and conclusions.

2.2 Related literature

2.2.1 Virtual communities during disasters

During a disaster, informational needs increase significantly due to high levels of uncertainty (Jurgens & Helsloot, 2018; Palen & Hughes, 2018). As a result, people often gather on social media to create or appropriate existing virtual communities to reduce uncertainty about the situation, praise each other's efforts, validate information and provide psychological and social support to victims (Nan & Lu, 2014; Procopio & Procopio, 2007; Qu et al., 2009; Tim et al., 2017; Vieweg, Palen, Liu, Hughes, & Sutton, 2008). For example, during Hurricane Katrina in 2005 (Vieweg et al., 2008), the Sichuan earthquake in 2008 (Nan & Lu, 2014), Cyclone Yasi in 2011 (Taylor, Wells, Howell, & Raphael, 2012), and the Thailand flood in 2011 (Leong, Pan, Ractham, & Kaewkitipong, 2015), virtual communities were appropriated or created to seek and provide disaster- related information, disseminate information about missing persons and facilitate relief efforts.

Virtual communities are not typically designed for disaster response. Compared with physical communities, virtual communities have weaker social forces to keep members in a community; members can easily join or leave (Faraj et al., 2011; Kim, Kim, & Kim, 2020). During a disaster, information of importance tends to be generated by specific sets of virtual community members - people on site (i.e., local individuals) and people who possess expert knowledge. However, many virtual communities face challenges regarding the presence of uncivil behaviours that can impact public perception of the virtual community and encourage people to withdraw (Luna & Pennock, 2018). Consequently, it is crucial for virtual communities to understand the processes by which SoC develops during times of disaster to prevent the loss of local and other valuable members and their contributions. Existing IS studies have primarily explored why people seek information from virtual communities in disaster events and what information they usually create, share and exchange (Leong et al., 2015; Nan

& Lu, 2014; Qu et al., 2009; Tim et al., 2017). However, how SoC can be constructed and help encourage virtual community members to generate VAR information in times of disaster is little understood.

2.2.2 Sense of Community

Sense of Community (SoC) is one of the key psychological dimensions relevant to disaster affected communities (Norris et al., 2008). A well-developed SoC fosters stronger social support and increases community participation in disaster response, thus reducing situational uncertainty and increasing the safety of community members (Bergstrand, Mayer, Brumback, & Zhang, 2015; Kim, Nakanishi, Blackman, Freyens, & Angela, 2017). Once SoC is established, community members exhibit community-like behaviours and social processes such as exchanging support, building trust, and maintaining norms and rules (Blanchard & Markus, 2004; McMillan & Chavis, 1986). Such social processes are mostly self-governed and emerge from within the community. SoC is a psychological property of a community that makes information reliable and trusted (i.e., helping generate VAR information) (Kim et al., 2020). Constructing a sense of community requires four elements in physical settings: *(1) membership, (2) influence, (3) needs fulfilment, and (4) shared emotional connection* (McMillan & Chavis, 1986). These four elements dynamically interrelate to construct a SoC in physical communities.

Membership represents the feelings of belongingness or personal relatedness, akin to identification with the collective (Garrett, Spreitzer, & Bacevice, 2017; Naranjo-Zolotov, Turel, Oliveira, & Lascano, 2021). Membership provides boundaries for community members (i.e., knowledge of who belongs to the community and who does not) through a common symbol system (e.g., community logo, name). As a result, members can identify themselves as part of the community, feel emotionally safe, and participate in community issues. Membership

also fosters loyalty and facilitates the regulation of community behavior (Hsu & Liao, 2014; Naranjo-Zolotov et al., 2021).

Influence refers to a sense of mattering, of making a difference to a community, and of the community mattering to its members. It means that a member can sway the decisions or opinions of other members and vice versa (Naranjo-Zolotov et al., 2021). People feel attracted to communities where they feel they have influence. Influence fosters a community's cohesiveness and conformity (Abfalter, Zaglia, & Mueller, 2012). Moreover, it encourages members to personally invest resources such as time and effort to solve community issues (McMillan & Chavis, 1986). As a result, members' trust is developed within the community (Capece & Costa, 2013).

Needs fulfilment represents reinforcement, shared values, and the feeling members have that their needs will be met through mutual support (Garrett et al., 2017). People like to engage more with a community that provides more resources or demonstrates an ability to resolve community issues. A strong community integrates members and prioritizes its need-fulfilment activities (Chih, Hsu, & Liou, 2017; McMillan & Chavis, 1986).

Finally, ***shared emotional connection*** represents the feelings of relationship, quality interaction among members, sharing similar experiences, history, time, and a spirit of community (Chih et al., 2017; McMillan & Chavis, 1986). Once more people start interacting, they are more likely to form sympathetically intimate relationships (Capece & Costa, 2013) which leads to stronger bonds (Abfalter et al., 2012) thereby infusing the community with a greater sense of purpose.

There are two theoretical streams on constructing SoC in virtual communities in non-disaster situations, neither of which provides sufficient understanding to guide decision making. One stream of research gives prominence to socialization among community members

and neglects the need for formal control (Blanchard, Welbourne, & Boughton, 2011; Capece & Costa, 2013; Faraj et al., 2011; Sproull, 2011). The second stream highlights the advantages of formal control (Carey & Meyer, 2016; Petrič & Petrovčič, 2014). It argues that formal control can help control uncivil behavior, hence promoting a SoC. However, recent research suggests that both socialization and formal control can co-exist in virtual communities (Dosono & Semaan, 2019; Spagnoletti, Resca, & Lee, 2015). However, how they relate to each other remains an open question. This lack of understanding may result in ineffective interventions and conclusions concerning the efficacy of SoC during disasters.

Socialization refers to the inculcation and transmission of community values, rules and norms (Maccoby, 2007; Sukel, 1983). Socialization teaches us how to behave in accepted ways and helps us to minimize uncivil behaviours (Blanchard et al., 2011; McMillan & Chavis, 1986). Social interaction among members is the foundation of socialization (Abfalter et al., 2012; Mamonov, Koufaris, & Benbunan-Fich, 2016). Socialization generally consists of two aspects: (1) norm formation and (2) norm enforcement via informal control. In virtual communities, people usually recognize each other through their username. While socializing, members create norms and acquire a shared identity (Ahuja & Galvin, 2003; Blanchard et al., 2011). Norms are shared cognitions on the basis of which a group of people manifest routinized behavior (Bettenhausen & Murnighan, 1985; Ivaturi & Chua, 2019). Norms are informal, unwritten, and arise from repeated interactions among members over time (Chandrasekharan et al., 2018). Norms can help reduce falsehoods in virtual communities (Gimpel, Heger, Olenberger, & Utz, 2021). Furthermore, norms promote greater levels of trust in the community (Blanchard et al., 2011). However, humans have agency - the ability to obey or reject any rule or norm (Giddens, 1984). One way of enforcing norms is via informal control. Informal control means unwritten, implicit forms of control based on shared norms/values/beliefs (Kreutzer, Cardinal, Walter, & Lechner, 2016). While socializing, community members can enforce

informal control (e.g., members correcting each other's' inappropriate behavior) with minimal reliance on formal authorities (e.g., moderators) (Chua, Wareham, & Robey, 2007; Long & Perkins, 2007). Applications of informal control include peer pressure, disapproval, questioning deviant behavior, monitoring, and reporting to moderators (Watson, Peng, & Lewis, 2019). It has been demonstrated that informal control can foster SoC in physical communities (Long & Perkins, 2007). It acts to empower communities and to give users a sense of having some control over community issues (Caffrey & Gary, 1997). As a result, people feel they can trust their co-residents and feel safe in their communities (Forrest & Kearns, 2001). However, prior findings of SoC in virtual community research suggest that informal control can erode an individual's SoC (Blanchard et al., 2011). The act of regulating others or the observance of being regulated causes a loss of the perception of SoC because people feel they are not alike - the regulated are not the regulators and vice-versa (Blanchard et al., 2011).

During a disaster, socialization may be insufficient to construct a SoC in virtual communities. Socialization is a bottom-up process (i.e., it emerges from within the community), and norms usually take time to institutionalize through this process (Chandrasekharan et al., 2018; Savage, 2019). However, disasters are time-sensitive and require rapid intervention by the community to minimize risks, such as preventing falsehoods. In addition to socialization, therefore, there is growing evidence that virtual communities can have formal control that involves top-down management (i.e., moderators) quickly imposing norms to minimize risks (Petrič & Petrovčič, 2014; Wise, Hamman, & Thorson, 2006).

Formal control means officially sanctioned institutional mechanisms, such as written rules, procedures and policies (Kreutzer et al., 2016). In virtual communities, formal control is created and enforced by moderators (Watson et al., 2019). Research suggests that formal control can help foster a SoC in virtual communities (Carey & Meyer, 2016; Petrič & Petrovčič, 2014) by making community values explicit, defusing conflict before it escalates, fostering

institutional trust (i.e., trust in rules), and helps build supportive relationships between members (Matzat & Rooks, 2014). By reducing the presence of insensitive or aggressive comments and repetitive information, moderators create a safe environment that encourages participation and improves SoC (Carey & Meyer, 2016; Sood, Churchill, & Antin, 2012; Wise et al., 2006). Moderators can guide discussions, ensure the discussion is conducted in a civil manner, and suspend users who act in an uncivil manner (Badreddine & Blount, 2021). Furthermore, moderators can also build and enforce norms in virtual communities (Ivaturi & Chua, 2019). However, moderator-imposed norms can create several issues. First, they can cause member disengagement or attrition (McWilliam, 2000). Research has demonstrated that moderators can be too sensitive and unwilling to accept criticism. Hence, they perform arbitrary moderation (i.e., self-censorship) which can have negative impacts on the individual's SoC in virtual communities (Perrault & Zhang, 2019; Wolfgang, 2019). Arbitrary moderation occurs when moderators force community members to conform to expectations (i.e., following norms and rules imposed by the moderators). As a result, people experience negative emotions (e.g., resentment) and feel treated unfairly. Second, they can fuel conflicts in the community when there is misalignment of expectations between users and moderators (Petrič & Petrovčič, 2014; Wright, 2005). Therefore, when moderators firmly enforce rules and norms, they face the risk of member dissatisfaction (Carey & Meyer, 2016).

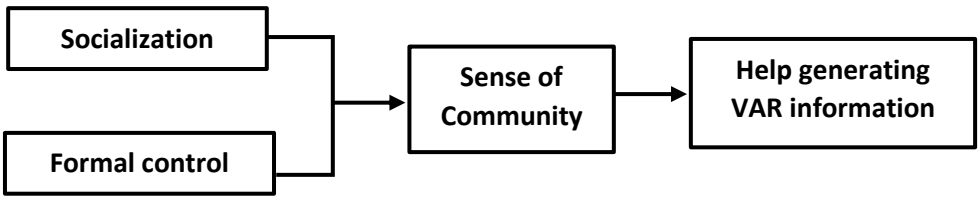

Figure 2. 1 Framework of constructing SoC in a virtual community during disasters

To summarize, Figure 2.1 illustrates a framework of constructing a SoC in virtual communities during a disaster. The literature argues a combination of socialization and formal control can help construct a SoC. Once formed, SoC can help generate VAR information.

During a disaster, it is critical to have the presence of both norms and SoC in the community. However, institutionalizing norms via socialization is time-consuming. Hence, it can be beneficial for the virtual community to engage with formal control (i.e., via moderators). However, when the formal controller imposes norms, several potential issues arise, including eroding an individual's SoC. Therefore, how both socialization and formal control relate and work together during a disaster remains unknown. This paper seeks to address this gap.

2.3 Methodology

We performed an in-depth qualitative case analysis of a virtual community focusing on how it responded to a disaster. We adopted an interpretive approach to gain an in-depth understanding of how a virtual community can foster SoC to help generate VAR information in times of a disaster (Klein & Myers, 1999).

2.3.1 Case site

Hurricane Harvey made landfall near Corpus Christi, Texas on August 25, 2017. The category 4 hurricane brought historic rainfall and left millions of residents without power. Later, Harvey moved slowly inland towards Houston, where it remained for four days and caused extreme flooding. According to the National Hurricane Centre, it damaged over 200,000 homes, resulted in 70 deaths, and caused USD 125 billion in damage (Cheong & Babcock, 2021). Residents in the area ran low on food, safe water and gas. The official emergency number, 911, was overloaded (Luna & Pennock, 2018). When victims could not receive effective help from official channels, they turned to virtual communities to call for help (Li, Stephens, Zhu, & Murthy, 2019). The National Hurricane Centre ceased tracking Harvey's remnants on August 31.

Community-generated archival data in Reddit was our main data source. Reddit is a social news aggregation and discussion forum of self-governed virtual communities. We chose

Reddit for two reasons. First, in other well-studied disaster virtual community platforms like twitter, communities are intermingled with diverse populations and topics. Thus, information concerning the disaster is not easily identifiable. It is, therefore, difficult to observe how a particular disaster affected community could develop SoC. By contrast, Reddit divides itself into topic-based communities called subreddits that are formed, maintained, and participated in by pseudonymous users. Within subreddits, registered users can create threads upon which others can upvote, downvote, comment and reply to comments (Davis & Graham, 2021). They can also report problematic users or contents to the moderators using the report button. Second, Reddit data is archived and open to the public, making data collection straightforward.

We chose the r/Houston subreddit (i.e., a virtual community on Reddit) as our case site for two reasons. First, this subreddit focuses on local issues, people, and events pertinent to the Houston area thereby allowing us to explore how a specific disaster- affected community engaged in surviving Hurricane Harvey. Second, critical to our research context, substantial activity arose in the r/Houston community during this hurricane. Table 2.1 summarizes activities of the selected case site.

Number of members (as of 25 August 2017)	62000+
Disaster response period: Aug 25- Aug 31,2017	Total number of threads created : 5315
	Total number of comments made : 99078

Table 2. 1 Summary of the subreddit (virtual community) used

2.3.2 Data collection and analysis

Data collection and analysis were done iteratively. The database of Reddit threads and comments from 2005 until the end of 2019 (more than 3 billion) are available on Google Big Query (https://cloud.google.com/bigquery/public-data) and PushShift (i.e., a social media data collection and archiving platform), which we used to obtain the data. We first collected all

threads in the two weeks during the hurricane (August 25-August 31, 2017) from the selected case site. The focus of this study is on how SoC can be constructed and maintained in virtual communities during a disaster. Therefore, the focus of our analysis was the threads (and associated comments) that were created around the time of the Hurricane Harvey.

We analysed the data using the concepts of *socialization*, *formal control* and *SoC* based on definitions from the literature.

Socialization. In our coding, we observed that both members and moderators participated in socialization activities. A piece of evidence was considered supportive of socialization if it signaled the formation of new norms/rules/beliefs or identification with others. We also observed what the community user/moderator did to form new norms/rules/beliefs. For example, members formed an emergent group norm of posting personal information, and the moderator acknowledged their request. Furthermore, we looked for evidence of informal control. Informal control was identified if community members relied on new norms/values/beliefs to regulate behaviours. For example, they reported fake news and problematic users to the moderators. Furthermore, we also observed how the community reacted to the informal control. While coding, we also observed emergent leadership. Evidence was coded as emergent leadership when a member assumed responsibility, took the initiative, and liaised with the moderators.

Formal control. Formal control was identified when moderators created new or enforced existing mechanisms (e.g., norms, rules, procedures, and policies) to moderate the community. For example, moderators banned problematic users. We also observed how the community reacted towards the formal control.

Sense of community was evaluated based on the presence or absence of SoC's four dimensions. A specific piece of evidence could map to multiple SoC elements.

Membership. Membership was assessed based on the comments or activities indicating boundary (i.e., in-group/out-group), reflecting members' safety (reveal how one feels about the community), expressing members'/moderators' involvement and sense of belonging.

Influence. Influence was assessed based on the comments suggesting, planning or taking actions and conforming to community norms and rules.

Needs fulfilment. Needs fulfilment was observed based on the comments related to seeking, providing or integrating situational information, advice, and suggestion. We also noticed what activities members/moderators performed during the hurricane Harvey so the community could satisfy members' needs.

Shared emotional connection. The shared emotional connection was assessed based on the comments expressing gratitude (praising community members/moderators) and sharing similar experiences.

2.4 Findings

Our findings address how SoC can be constructed and maintained in virtual communities during a disaster. The three scenarios discussed below illustrates (1) what problematic situations arose during the disaster and (2) how socialization and formal control contributed (or did not contribute) to the construction of SoC thus help generating VAR information.

Scenario 1- Managing the Spread of Falsehoods

Problematic situation: While the target market of r/Houston is individuals living in Houston or who have a connection with Houston, the community allows others (i.e., individuals not from Houston) to participate. During the hurricane, individuals from both Houston and outside of Houston visited the community. Disaster victims (i.e., individuals from Houston) wanted to

survive. While many outsiders provided well-intentioned assistance, other outsiders had a non-survival agenda (e.g., propagate rumours, fake news). For example, an outsider propagated a rumour of a shark swimming on the freeway of Houston.

"*My wife saw this [photo of a shark swimming] on her Facebook feed. Believe it or not, this is a shark on the freeway in Houston, Texas."*

Before the hurricane, the r/Houston subreddit welcomed all kinds of discussion related to Houston including making claims without supporting evidence. The community moderators did not explicitly specify any rules regarding posting falsehoods.

Socialization: *Emergent group norm formation:* During Hurricane Harvey, the term 'Houstonian' became popularized and individuals living in Houston identified themselves as 'Houstonian.' The community favoured Houstonians and helpful outsiders over problematic outsiders.

"What Houstonians need are other locals who actually know what's going on. Not non-locals (who don't know shit about what's going on) tossing blame at this official and that official."

Another community norm emerged that any informational posts must be backed by evidence (e.g., an image or a video) or by a link to official sources.

"I repeat stop asking questions here there is only two acceptable comments in this thread that won't get you downvoted: 1. Picture/description of where water is. 2. Some sort of caring "stay safe friends" comment."

Moderators became aware of the community preference (i.e., members gave prominence to Houstonians and other helpful outsiders) and norms of attaching evidence by actively participating in the conversation. For example, they provided a link to an official source and asked the original poster to delete the shark rumour.

"Delete. Along with anything else on here: https://www.washingtonpost.com/news/the-intersect/wp/2017/08/28/no-the-shark-picture-isnt-real-a-running-list-of-harveys-viral-hoaxes/?utm_term=.1346b2f3ab6c"

Informal control: Members reported problematic outsiders to the moderators. Community members spotted users who propagated falsehoods and asked for evidence. They gave many up-votes on the evidence-based informational posts and those without evidence were down-voted.

"What is your "reliable source"? Clear Lake City Water Authority issued a statement that rumours on social media that the water supply is threatened are false."

Formal control: Moderators banned unwanted users who were not from Houston. This helped the community to maintain the in-group/out-group distinction between Houstonians and problematic outsiders. The below comment is made by a moderator.

"He's already been banned. His second account has also been banned."

Moderators also endorsed the new norm of attaching evidence and played an influential role by enforcing this emergent group norm. They encouraged members not to spread any falsehoods. For example, a person claimed that the city of Houston was shutting down the water supply. However, this was a rumour.

"I've seen no evidence of that. Please encourage them to not spread information without a source."

Sense of community and generating VAR information: Community members participated to correct falsehoods which demonstrates the personal influence of members within the community. For instance, a member was trying to share external news that circulated in a WhatsApp group. However, this member was not sure about the authenticity of the information. After realizing that the news was a false rumor, he deleted the news link (influence: conforming to norms).

"This was on one of the whatsapp group... I don't believe that's true…but just wanted to share…will delete if mods think it is spreading rumor... thoughts? EDIT: Deleted to avoid spreading rumors."

People started attaching evidence such as images while seeking help or providing information. Users found this evidence useful and appreciated those who provided it (influence/shared emotional connection):

"Thank you for actually posting evidence instead of telling people to go find it."

As a result, members started relying on the given sources and acknowledged that r/Houston provided informative news during Hurricane Harvey (needs fulfilment). They also expressed how the community-generated contents influenced them to subscribe and be a part of this community.

"This subreddit gave me better news than I would have gotten anywhere else, I would have been completely blind, so having this here is wonderful."

Scenario 2- Simplifying the Search for Information

Problematic situation: The needs and interests of the r/Houston community changed significantly during the hurricane. Most individuals needed rescue, basic necessities, and trusted sources of information. Furthermore, they needed specific local information. Initially, the community created individual threads or commented on the existing threads to seek or provide information. However, the multitude of generated threads made it difficult to find specific useful information as such information was scattered across multiple threads. For example, one person was unable to find emergency numbers that were posted earlier by others.

"Where to find emergency numbers? I tried but was unable to find them."

Many users continued posting irrelevant and non-useful information including politics and callous comments such as the one below:

"You guys deserve this. Why didn't you evacuate, you f[expletive] moron. My fiancé and I are enjoying hurricane Harvey."

Socialization: *Emergent group norm formation:* A member (hereafter called emergent leader) noticed the problem and suggested a moderator (by tagging the moderator) create a dedicated thread placed on top of the pile of threads (called a megathread) so all information would be gathered in a central place. Several other members voiced their support for the suggested solution.

"Fun times ahead. Hopefully the mod [moderator] team can create a megathread for the tropical storm? /u/ [moderator's name withheld]?"

Moderators listened to the suggestion and agreed to create megathreads for each day of the hurricane. Before the hurricane, the community allowed users to create individual threads or comment on the existing threads if they want to seek or provide information. However, a new norm emerged that people should seek and provide information in the megathread instead of creating individual threads.

Informal control: Many members pressured others to seek information in the megathread instead of creating individual threads.

"Look at megathread. Don't make posts like this."

Members also confronted political and insensitive comments and reported them to moderators. For example, one member suggested political comments be moved to another subreddit.

"Take this s[expletive] to /r/politics. People are using this sub [subreddit] as a means of communication about what is happening on the ground in an important time. You'll have plenty of time to s[expletive] on Trump after all this is over."

Moreover, they asked moderators to remove political and callous comments.

"Mods, you should delete all this s[expletive] insensitive comments."

Formal control: During the hurricane the moderators were outside of Houston. Creating a megathread required moderator permission. Hence, the moderator granted the

emergent leader (who suggested the solution) temporary moderator status. He then started creating the megathread.

"It was always the understanding that I was going to be a guest mod [moderator]…that way, I could sticky the megathreads and delete trolling comments in those megathreads."

While many members followed the dedicated thread others still created individual threads. The emerging leader (temporary moderator) redirected their questions to the megathread.

"Please post in the megathread. Thanks!"

The moderators (including the emergent leader) explicitly listed community rules and enforced them to ensure members' emotional safety and protect group intimacy. Besides, they also encouraged users to avoid personal attacks and name-calling.

"Spirited debates are great, but if you have to resort to personal attacks you've already lost. Name-calling can result in bans from the subreddit."

Sense of community and generating VAR information: Members started contributing and following the megathreads to fulfill their needs. The community met members' needs through mutual support. Some members were seeking situational information whereas others were describing the situation of a place, providing advice or suggestions as well as sharing official sources (needs fulfillment). For instance, one person was asking where to volunteer and received replies from community members.

"I would like to know where to volunteer. Let's come together."

"At GRB. Volunteers should check in at the check in booth by the pappadeaux on the corner closest to the Toyota Center. Get a wrist band and start asking where they need help."

Many members directed others to the megathreads and shared their appreciation for the moderators for their efforts (influence/shared emotional connection).

"Much acclaim and appreciation to our moderators for helping to disseminate all of this valuable information. I've directed so many people to this megathread because of your amazing work. Thanks again, guys and girls! Your hard work and dedication does not go unnoticed or appreciated."

Moderators also showed gratitude towards members and especially thank some members who had a significant contribution (shared emotional connection).

"I've been astounded by how everyone on in /r/Houston has worked together through this horrible and unprecedented situation. A huge thanks to the community and everyone who has been monitoring the megathreads and giving invaluable advice to people in need. I'm really proud to live in Houston and see how well everyone came together in a time of crisis."

Scenario 3- Changing Rules to Help People

Problematic situation: During the hurricane, members needed rescue or emergency supplies to be provided at a specific location. However, posting personal information (e.g. address, contact details) was against the community rules and Reddit policy. This meant it was not possible to send or obtain support during the disaster without knowing the physical location of the victims. Initially, moderators strictly followed rules and took down threads or comments with attached personal information. They mentioned the community rules:

"Posting personal information, harassment, and other breaches are strictly forbidden."

While some members questioned such moderation practices and asked for justification, other members reminded people not to post personal information.

"Hey you will get banned in half a second if you ask that [address]. The mods [moderators] are fucking crazy."

People became dissatisfied and wanted to leave the community.

"I must say mods are dumb. Time to leave this sub [subreddit]."

Socialization: *Emergent group norm formation:* A norm emerged among the members that moderators should allow posting personal information. For example, a member suggested victims should share their zipcode to indicate location. They asked moderators to relax rules

on self-disclosure. Moderators acknowledged members' feedback and agreed to allow the posting of personal information.

"People should hashtag their zipcode so people with boats who are volunteering can filter who is in their vicinity."

Informal control: While a few members continued to advocate against making private information public, the majority disapproved and encouraged the posting of personal details.

"Drown or stay anonymous take your pick."

Formal control: Moderators relaxed rules on posting personal information. They also created a new digital identifier called a "flair" to indicate the location of the information seeker/provider.

"You can now share your address and contact details if necessary."

Sense of community and generating VAR information: People started providing personal information and received the required support (influence/needs fulfilment). For example, one person posted an address to get rescue assistance.

"My friends are stuck in their home, they need rescue. Here's the exact address it's [house address]"

Community members appreciated those who helped in the rescue effort (shared emotional connection).

"You have such a big heart, thank you for rescuing them."

2.5 Discussion

A sense of community improves the spread of verifiable, accurate, and reliable (VAR) information during a disaster. Research suggests virtual communities can enforce norms to foster a SoC thereby improving VAR information (Blanchard et al., 2011; Petrič & Petrovčič, 2014). Prior work highlights the importance of socialization and formal control as a means of norm enforcement (Blanchard et al., 2011; Petrič & Petrovčič, 2014; Watson et al., 2019; Wise

et al., 2006). However, institutionalizing norms via socialization is time-consuming. Hence, research suggests imposing norms via formal control. However, norms imposed by formal control can cause conflicts and erode individuals' SoC. Therefore, it remains unknown how both socialization and formal control can act together to foster a SoC in virtual communities during a disaster. Our findings suggest two processes, *endorsing* and *disciplining*, interacting between socialization and formal control, can together foster a SoC.

Concepts	**Case evidence from the r/Houston community**
Socialization	• Members made their needs explicit • Members formed emergent group norms • Emergent leader tagged moderators to inform concerns and suggest solutions • Moderators acknowledged emergent group norms and feedbacks • Moderators recognized emergent leader • Members reported falsehoods and unwanted users to the moderators • Members confronted and reported insensitive comments to the moderators • Members spotted falsehoods and asked for evidence
Formal control	• Moderators took down threads or comments for violating emergent group norms and community rules • Moderators banned unwanted users • Moderators removed insensitive comments • Moderators granted authority to emergent leader
Sense of Community	• Reinforced membership through in-group/out-group distinction • Members followed emergent group norms and community rules • Members actively corrected falsehoods • Improved shared emotional connection and social support
Outcome	• Helped generating VAR information

Table 2. 2 Summary of findings

We have demonstrated how socialization and formal control contributed to the formation of SoC in the r/Houston community. Socialization can inform formal controllers (i.e., moderators) about how emergent group norms work, transfer community feedback, and introduce emergent

leadership through the endorsing process. At the same time, formal controllers can improve socialization through the disciplining process. They can enforce emergent group norms, sanction uncivil behavior, and authorize emergent leadership. Table 2.2 summarizes the key points of our findings. Figure 2.2 illustrates our revised framework of constructing and maintaining a SoC in virtual communities during a disaster.

How socialization and formal control interact: the virtuous cycle of endorsing and disciplining

One reason moderator imposed norms can create conflict and hinder an individual's SoC is the misalignment of expectations among community users and moderators (Carey & Meyer, 2016; Petrič & Petrovčič, 2014). Imposing norms via formal control discourages users from seeking and providing support. For example, in our case, it was not possible to get support without disclosing personal information during the hurricane Harvey. Therefore, while socializing, members formed the emergent group norm of posting personal information. However, posting personal information was against Reddit policy. Therefore, initially, moderators removed posts that contained personal information. This led to members becoming dissatisfied and wanting to leave the community.

The simultaneous existence of socialization and formal control raises an important question. How can one make sure the norms imposed by formal control work? Our findings suggest that moderators need to impose emergent group norms instead of moderators' norms. This poses another question of how moderators get informed of emergent group norms. Our case illustrates moderators can learn about emergent group norms and changing needs of the community through a communicative process. We refer to this process as *endorsing.* During this process, the community members highlight their specific disaster-information needs and form emergent group norms (e.g., posting personal information, attaching evidence, isolating

unwanted users). The moderation team learns about these emergent needs and norms by actively participating in the conversation. They listen to community feedback and formalize emergent group norms.

As part of the endorsement process, it can be useful for moderators to recognize emergent leaders. Our findings suggest that moderators must be sensitive to community sentiment during a disaster and emergent leaders are often more sensitive to comments from people on the ground than prior moderators. In our case, the emergent leader identified solutions to address the community's unique needs during the disaster. The emergent leader acted as a conduit and helped channel emergent group norms to the moderators. Our findings resonate with other studies that demonstrate the importance of emergent leadership during disasters (Gardner, 2013).

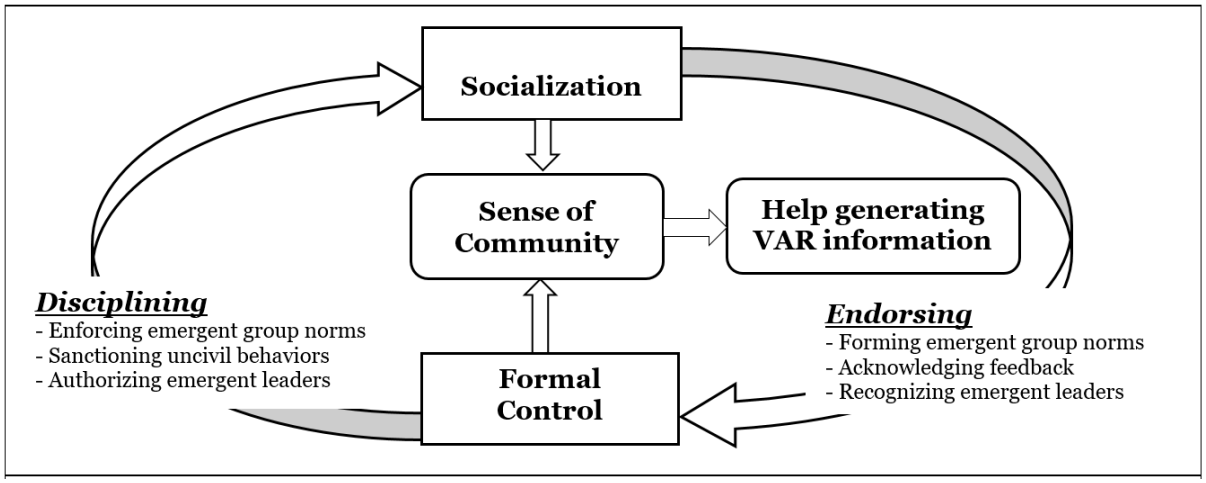

Figure 2. 2 Revised framework of constructing a SoC in virtual communities during disasters

It is also necessary to regulate uncivil behaviours and isolate problematic users from the community during a disaster. The moderators enforced emergent group norms and sanctioned uncivil behaviours through an enforcement process. We refer to this process as *disciplining.* Prior work argues virtual communities should be open and inclusive (Pi, Chou, & Liao, 2013; Rheingold, 1993). Furthermore, they should encourage uninterrupted

participation because regulating one's behavior can erode individual-level SoC (Blanchard et al., 2011; Meyer & Carey, 2014). However, our findings suggest that isolating problematic users and losing individual-level SoC improved SoC at the group level during the disaster. For example, the community only preferred Houstonians and helpful outsiders during the hurricane. Thus, that non-Houstonians lost individual-level SoC and stopped participating was desirable. Members reported problematic users, and subsequently, moderators banned them. As a result, the community reinforced its membership and received desired support. We also noticed moderators granted the emergent leader temporary moderator status to exert formal controls. Subsequently, the emergent leader made community rules explicit and also regulated uncivil behaviours. We agree with prior studies that alienation at the individual-level can erode an individual's SoC (Blanchard et al. 2011). Moreover, alienated individuals have lower trust in others. However, we argue this is a desirable outcome so long as the individuals alienated are not the ones the virtual community wants during the disaster.

2.6 Conclusion

This paper has addressed the question of how a self-governed virtual community can construct and maintain a sense of community during a disaster. Our evidence suggests that though disasters create chaos and uncertainty, they also provide an opportunity for constructing a sense of community within the virtual community. We demonstrate that socialization and formal control are essential factors in virtual communities to minimize disaster-associated risks (e.g., anti-social social behavior, falsehood propagation). Together, these factors create a virtuous cycle. Our findings reveal that when moderators impose emergent group norms, sanction uncivil behaviours, and isolate problematic users via the processes of endorsing and disciplining, they can improve the sense of community at the group level.

Our findings have several implications for virtual community moderators. First, moderators should actively participate (socialize) in the community to learn the changing needs and emergent group norms during a disaster. This will help moderators adjust their moderation practices according to changing needs. Second, moderators should sanction uncivil behavior and isolate problematic users. Finally, moderators should recognize emerging leaders, cooperate with them, and grant them appropriate power.

This study has a number of limitations. First, the empirical support of our findings is limited to a single virtual community in Reddit. Hence, the virtuous cycle may not be plausible for all virtual communities on other platforms (e.g., Twitter). Second, it covers only one disaster incident in one country. We acknowledge that each disaster and each country is unique. Third, our study only focuses on the disaster response period. However, a sense of community may develop over time. Hence, there may be other factors contributing to SoC that should be explored in future research. Future studies might confirm whether our proposed framework applies to other disasters more generally.

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CHAPTER 3. DISSEMINATING TRUSTED HYPERLOCAL INFORMATION

Abstract

Disasters create uncertainty, chaos and panic. Providing timely and trusted information where it is needed is key in effective disaster response. Many disaster incidents have been documented where virtual communities act as information providers to reduce victim uncertainty about the situation and support recovery. However, information overload, overlap and falsehoods hinder information flow in virtual communities, which puts disaster victims at risk. This study examines how virtual communities can disseminate truthful, useful information quickly during times of disaster, while simultaneously suppressing false and irrelevant information. Through an in-depth case study of a virtual community focused on a natural disaster response, our findings suggest that the key role of a virtual community in times of disaster is to manage and disseminate the transformation of authoritative information into trusted hyperlocal information. Using the theory of the risk society, we find one successful transformation is for the virtual community to *(1) create a controlled information hub, (2) promote identity revelation, and (3) allow for temporary emergent hyperlocal leadership*. Our findings contradict earlier IS research that suggests anonymity, openness and geographical dispersion are important for information dissemination in virtual communities. During a disaster these policies may need to be reversed.

3.1 Introduction

Disasters (e.g., hurricanes, earthquakes, and pandemics) inherently create uncertainty, chaos and panic. During disasters, people seek and share information across multiple information channels (Jurgens & Helsloot, 2018; Nan & Lu, 2014; Palen & Hughes, 2018; Roy, Hasan, Sadri, & Cebrian, 2020). The uncertain character of a disaster, however, makes the rapid provision of information challenging for all stakeholders (Ludwig, Kotthaus, Reuter,

Dongen, & Pipek, 2017; Turoff et al., 2011). Disaster victims are especially affected as they require quick assistance and reliable information (e.g., the availability of shelters and resources). Although authoritative sources provide substantial information for the public, the information provided by these sources is often not directly actionable (Ludwig et al., 2017; Shklovski, Palen, & Sutton, 2008; Tim, Pan, Ractham, & Kaewkitipong, 2017), but must be transformed so disaster victims can use it. For example, authoritative sources might provide a list of shelters during a hurricane, but a disaster victim needs to know the directions to the closest available shelter. This might not be the closest shelter geographically if roads are blocked.

Disaster incidents have been documented where virtual communities act as information providers to reduce victim uncertainty (Houston et al., 2015; Jurgens & Helsloot, 2018; Qu, Wu, & Wang, 2009). A virtual community is "a group of people who communicate and interact, develop relationships, and collectively and individually seek to attain some goals in an IT-supported virtual space" (Ma & Agarwal, 2007). For example, people turn to virtual communities to determine a disaster's magnitude, intensity, and exact location and to keep themselves, their family and friends safe.

However, as most virtual communities are not designed to help with disaster management (Nan & Lu, 2014; Qu et al., 2009; Reuter & Kaufhold, 2018), it is possible for virtual communities to adversely affect disaster victims. Virtual communities can amplify chaos and increase uncertainty during disasters (Arif et al., 2016; Oh, Agrawal, & Rao, 2013). One reason for this is that many virtual communities support open participation and anonymity (Fatima et al., 2019; Lu & Yang, 2011; Prakasam & Huxtable-Thomas, 2020). Anonymous individuals can spread falsehoods and detrimental information (e.g., spam, scams) which worsen a disaster victim's situation (Luna & Pennock, 2018). For example, inaccurate weather reports and incorrect shelter locations were disseminated during Hurricane Sandy in 2012

(Luna & Pennock, 2018). During the Covid-19 outbreak, claims were made that the virus is a bioweapon, or coconut oil kills the virus (Pennycook, McPhetres, Zhang, & Rand, 2020). These false narratives can cause significant harm by, for example, fuelling racism or influencing individuals to engage in risky behaviour.

A second reason is that virtual communities are typically not designed to be hyperlocal, but during a disaster, people's needs and interests are hyperlocal – people need trusted sources of information about rescue or emergency supplies that are available at a specific location. Information that is of a more general nature (even if trusted and authoritative) might be largely irrelevant.

This study, therefore, seeks to address the research question: ***How can virtual communities provide trusted hyperlocal information during a disaster?*** How virtual communities can mitigate risks while effectively disseminating trusted information (i.e., verifiable, accurate, and reliable information) to where it is needed in times of disaster remains an unsolved problem.

We conducted an in-depth interpretive case study of a virtual community, the r/Houston Reddit group, looking at how this community mitigated the risks associated with Hurricane Harvey. Hurricane Harvey was a Category 4 hurricane that made landfall in August 2017, leading to catastrophic flooding in the Houston metropolitan area and Southeast Texas. We use risk society theory (Beck, 1992; Beck, Giddens, & Lash, 1994) to analyse the information disseminated by the r/Houston Reddit group during and immediately after the hurricane hit. Risk society theory explores how social actors change existing institutions to systematically deal with emergent risks, in this case, to manage disaster information. Our findings suggest the key role of a virtual community in times of disaster is to manage the transformation of authoritative information into trusted hyperlocal information and to disseminate it. Authoritative information is information generated from traditional institutional sources (e.g.,

the government, disaster agencies). Hyperlocal information is information specific to a narrow geographic locale (e.g., a particular affected street). Our findings suggest that, during a disaster, a virtual community should (1) create a controlled information hub, (2) promote identity revelation, and (3) allow for temporary emergent hyperlocal leadership.

The paper proceeds as follows: the next section presents the theoretical background on virtual communities in disaster situations. We then discuss risk society theory and how it can be used to understand the risk mitigation process in virtual communities in times of disaster. The following two sections are our research methodology and findings. The final sections are the discussion and conclusions.

3.2 Literature Review

Virtual communities (e.g., Facebook groups, blogs, wiki, web discussion forums etc.) are typically self-organizing, voluntary, and open participation systems created and sustained through computer-supported communication (Lu & Yang, 2011). Whereas traditional territorial communities are linked to a physical area such as a neighbourhood, "virtual communities" are not defined by geographic boundaries (Faraj, von Krogh, Monteiro, & Lakhani, 2016; Ridings & Gefen, 2004). Instead, people with common interests (who are not necessarily known or identifiable) gather in online places (e.g., social media platforms), separated by time and space seeking common goals (Faraj, Jarvenpaa, & Majchrzak, 2011; Gerken, Bretschneider, & Hülsbeck, 2019). People use virtual communities for many purposes, such as exchanging information, building relationships, providing social support and for transactional purposes (Huang, Chengalur-Smith, & Pinsonneault, 2019; Kim, Chan, & Kankanhalli, 2012; Ridings & Gefen, 2004). Virtual communities enable people to build social relationships with acquaintances or strangers regardless of their geographic location (Faraj et al., 2016; Ridings & Gefen, 2004).

Active user engagement is a key factor to making a virtual community successful (Ren et al., 2012). However, since virtual communities are open participation systems, socially undesirable behaviours (e.g., trolling, name calling, rumour mongering) are not uncommon. These behaviours can impact public perception of the virtual community and encourage people to withdraw. Therefore, a virtual community must support a leadership structure that helps prevent such unacceptable behaviours (Chu, 2009; Chua, 2009; Ivaturi & Chua, 2019). Virtual community leaders can help the community thrive by controlling users' privileges, cultivating norms, organizing activities, leading discussions, and moderating content (Huh, Marmor, & Jiang, 2016; Ivaturi & Chua, 2019; Kilgo et al., 2016).

3.2.1 Virtual Communities in Disaster Situations

During a disaster, informational needs change significantly due to high levels of uncertainty (Jurgens & Helsloot, 2018). People need information from their fellow disaster victims on the ground as well as from authoritative sources. While authoritative sources including the mainstream media provide some useful information, they often fail to provide information at a sufficiently granular level (Ludwig et al., 2017; Oh et al., 2013). Information dearth (i.e., lack of hyperlocal information needed by disaster victims) is a common problem observed in many disaster situations. For example, people need to know which road is safe to access, the locations of open shelters, as well as evacuation instructions. As a result, during disasters, people often turn to social media or other digital platforms to create or appropriate existing virtual communities to reduce uncertainty about the situation. They praise each other's efforts, validate information, and provide psychological and social support to victims (Nan & Lu, 2014; Qu et al., 2009; Tim et al., 2017; Vieweg, Palen, Liu, Hughes, & Sutton, 2008). Documented evidence exists that during Hurricane Katrina in 2005 (Procopio & Procopio, 2007), the Sichuan earthquake in 2008 (Nan & Lu, 2014), Cyclone Yasi in 2011 (Taylor, Wells, Howell, & Raphael, 2012), the Christchurch earthquake in 2011 (Bunker, Ehnis, Seltsikas, &

Levine, 2013), the Thailand flood in 2011 (Leong, Pan, Ractham, & Kaewkitipong, 2015), and the Hurricane Maria in 2017 (Wyk & Starbird, 2020) virtual communities were appropriated or created to seek and provide disaster-related information.

The creation or appropriation of virtual communities for disaster information dissemination is not unproblematic. A common criticism is of the trustworthiness and relevance of the information generated by virtual community participants (Silver & Matthews, 2017). Previous research has demonstrated that virtual communities can be a source of misinformation (deliberate or unintentional) and rumors (Lu & Yang, 2011; Luna & Pennock, 2018; Oh et al., 2013; Roy et al., 2020; Silver & Matthews, 2017). This can create difficulties for disaster victims who often cannot differentiate between trustworthy and false information. For example, the Covid-19 pandemic has been described as an infodemic as well as a pandemic, where there is an overabundance of information, some accurate and some not (WHO, 2020).

Misinformation can cause significant harm to affected individuals (Abdullah, Nishioka, Tanaka, & Murayama, 2015). Many incidents have arisen where malicious users have disseminated misinformation in virtual communities during times of disaster (Luna & Pennock, 2018). For example, during the 2011 Japan earthquake and tsunami, wrong shelter locations were disseminated deliberately. False reports of explosions were propagated during the Mumbai terrorist attack in 2008. Because of the urgency of disaster situations, people often do not have time to authenticate information before sharing it with others (Rajdev & Lee, 2015). The open and anonymous nature of virtual communities makes it difficult to overcome these problems.

Information overload is another common problem during disasters (Hiltz & Plotnick, 2013; Oh et al., 2013). Information is disseminated by diverse sources (e.g., media outlets, emergency responders, humanitarian organizations, etc.) and relayed by virtual community participants. Such information can overlap and be contradictory (Rao, Plotnick, & Hiltz, 2017).

However, during disaster situations people need to obtain trusted information in a coherent manner that is easy to assimilate. This trusted information also needs to be hyperlocal, such as information about rescue or emergency supplies that are available at a specific location, rather than of a more general nature.

Prior studies have primarily explored individual motivations behind information exchange in virtual communities during disasters to address why people share information (i.e., psychological and informational support). Other studies have explored the role of social capital (Lu & Yang, 2011), boundary objects (Tim et al., 2017), self-organization (Nan & Lu, 2014) and empowerment (Leong et al., 2015) in information exchange. However, little work has explored how to simultaneously disseminate truthful, useful, hyperlocal information quickly in virtual communities while suppressing false, irrelevant information during a disaster. Since virtual communities are not typically designed for disaster response, we need to understand how virtual communities can be effectively managed in times of disaster to mitigate risks associated with disaster information dissemination.

Theoretical Framework: Risk Society and the Use of Social Technologies

In this paper, we draw on risk society theory as proposed by Beck, Giddens and colleagues (Beck, 1992; Beck et al., 1994). Giddens, who proposed structuration theory, in more recent years has adopted risk society theory. IS research has acknowledged risk society as a concept (e.g., D'Mello, 2005; Jacucci, Grisot, & Hanseth, 2004; Westergren & Holmstrom, 2008), although to our knowledge no one has applied it as a theoretical lens to leverage its key theoretical insights.

Risk society theory argues risk has become one of the main defining features of modern society (Beck, 1994; Giritli Nygren & Olofsson, 2020; Olofsson & Öhman, 2007; Straub, 2020). Risks are possible detrimental outcomes resulting from an event or human activity subject to hazard(s) (Hardy, Maguire, Power, & Tsoukas, 2020; Renn & Benighaus, 2013).

Given that risk is omnipresent, societies create institutions to manage risk. Institutions are widely diffused practices, technologies, rules, or organizational forms that enable and regulate social actors' behavior and make social life predictable (Hargrave & Van De Ven, 2006; Lawrence, Hardy, & Phillips, 2002). Key to risk society theory is that in our current society, risk is no longer caused only by external conditions (e.g., natural disasters) but also by modernity (i.e., a movement away from traditional forms of life or ideas) itself (Beck, 1992; Beck et al., 1994; De Donder, Buffel, Dominique, Sarah, & Nico De, 2009; Giddens, 1999; van Bueren, Lammerts van Bueren, & van der Zijpp, 2014). For example, global warming is associated with human activity (carbon emissions due to industrialization); nuclear power plant meltdown risks are wholly associated with human devices (viz. nuclear power plants). That the most dangerous risks to society arise from society itself creates the *"risk society,"* a world where risks are human-generated, complex, and insensible and threaten the existence of humanity on a large scale (Giddens, 1999; Giritli Nygren & Olofsson, 2020; Matten, 2004).

We suggest virtual communities are part of the risk society. Virtual communities are used for many purposes, such as exchanging information, building relationships, and for transactional purposes. During disasters, virtual communities are used to find and disseminate information. However, these self-same virtual communities create risks, because they can be used to spread falsehoods (e.g., misinformation, rumour) and promote socially unacceptable behaviours (Luna & Pennock, 2018; Oh et al., 2013). The same virtual communities used to help obtain useful information can be problematic and can generate more risks for the victims of a disaster.

In risk society theory, risk is a driving force for social change (e.g., a major source of solidarity) where social actors (e.g., individuals or organisation) systematically deal with hazards and insecurities stemming from modernity (Beck, 1992; Giritli Nygren & Olofsson, 2020; Olofsson & Öhman, 2007). Flaws in existing institutions render these institutions

incapable of mitigating emergent risks (i.e., risks that arise as a result of society changing) (Chan, 2008). One key flaw of existing institutions is *organized irresponsibility* (Ekberg, 2007; Matten, 2004; Mythen, 2018), which arises from the relationship between social actors (i.e., individuals and organisations). In organized irresponsibility, the individual social practices or actions of many social actors collectively generates risk for others, and because responsibility is diffused, no one takes responsibility (Beck, 1998; Curran, 2018; van Bueren et al., 2014).

As a result of organized irresponsibility, existing institutions (e.g., government agencies) that are supposed to control and manage emergent risks do not take responsibility and fail to address these risks. They flag these emergent risks as institutionally incompatible and chase other objectives single-mindedly instead. When incidents (e.g., accidents) arise as a result of emergent risks, humans in the risk society blame existing institutions for not acting appropriately (Béland, 2007). These humans alienate themselves from existing institutions and develop new trust systems (Beck, 2009; Hoogenboom & Ossewaarde, 2005; Wynne, 1996). Alternative forms of political interaction emerge, which in the risk society is called *"sub-politics"* (e.g., activist groups) (Beck, 1992; Beck et al., 1994; Chan, 2008). Sub-politics emerge when traditional institutions struggle to maintain their legitimacy, and new non-traditional social actors enter the debate (Beck, 1998; Guivant, 2016). Non-traditional social actors increasingly pressure and question the status quo. As a result, significant institutional change (i.e., reorganization of power and responsibility), and transformation occurs to cope with emergent risks (Chan, 2008).

Institutions arising from sub-politics also struggle to gain legitimacy while facing demands for solutions to solve emerging risks (Beck, 1994; Chan, 2008; Edmeston, 2010). Their actions only gain legitimacy when humans in the risk society become aware of the sub-politics and get involved in mitigating emergent risks. How legitimacy is obtained is highly situated. How others view and act towards the new institution arising from sub-politics in the

risk society is called *"reflexivity"* (Guivant, 2016; Olofsson & Öhman, 2007). Reflexivity is the capacity of social actors to show awareness and some kind of active strategy to handle risks (Giddens, 1990; Lash, 1994; Olofsson & Öhman, 2007). Reflexivity is thus an individualized response to the uncertainty and contingency that defines the risk society (Ekberg, 2007). Some people in the risk society confer legitimacy on the new institution while others resist it. Given a sufficient number of people, the new institution gains sufficient legitimacy to mitigate emergent risks. The risk mitigation process of risk society theory is depicted in Figure 3.1.

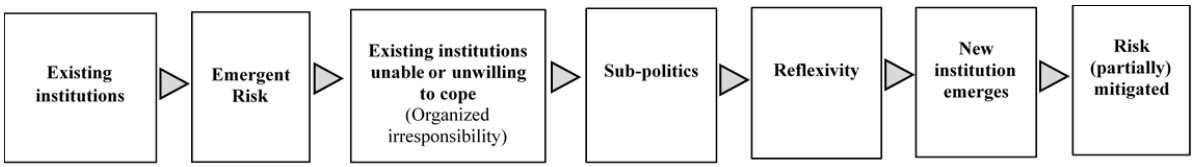

Figure 3. 1 A framework of risk mitigation

Risk society theory thus explores (1) the inability of existing institutions to cope with emergent risks, and (2) the institutional innovation required to mitigate emergent risks. However, while risk society theory does not explicitly consider the role of technology, we suggest that technological development plays a crucial role in transforming society (Jacucci et al., 2004). People use technology to both mitigate and create risks. For example, social bots were used during the 2011 Japan earthquake to automate earthquake warnings on Twitter (Haustein et al., 2016). However, social bots were also used to deliberately spread misinformation in the 2016 US election (Bessi & Ferrara, 2016). To fully understand the risk mitigation process in virtual communities, we believe it is important to understand the role of technology.

The kind of technology one can use depends on technological artefacts (e.g., features, tools) provided by technology platforms, i.e., a set of building blocks that act as a foundation upon which users may collaborate, participate, and develop technologies within the platform architecture (Choi, Nam, & Kim, 2019; Gawer, 2009). For example, Reddit is a technology

platform that allows users to form topical communities, within which users can create, comment and vote for posts (e.g., images, or URL links) (Hamilton, Bajaj, Zitnik, Jurafsky, & Leskovec, 2018). Twitter is another technology platform that provides technological artefacts such as hashtags to filter information with a theme or specific content.

During a disaster, existing technology-mediated institutions are prone to organized irresponsibility. For example, social media can be used to spread falsehoods about the disaster. Using the risk society lens, existing institutions (e.g., social media companies such as Facebook) initially abrogate responsibility for addressing these (organized irresponsibility). New technology-mediated institutions (subpolitics) should emerge as a result. However, this new technology will be constrained by technology platforms (Murthy & Gross, 2017; Qu et al., 2009). For example, if one is using Reddit, one's ability to filter messages is constrained by Reddit's technology for filtering posts. Furthermore, during the short period of most disasters, while technology can change (i.e., we can change the rules for accepting messages on a subreddit), the technology platform typically remains invariant - there is simply not enough time to change the technology platform. Thus, while the filters Reddit provides will remain constant, how those filters are adapted to create new ways of filtering posts will change. To illustrate, hashtags are an element of many social media technology platforms. During the 2011 Christchurch earthquake, local people used the #eqnz hashtag (a new technology) for co-ordination and relief efforts. However, innovations in the underlying hashtag technology did not appear on the social media platforms themselves. Figure 3.2 presents our framework of risk mitigation in virtual communities and illustrates the role of technology. The solid arrow represents the technology platform that remains invariant and the dotted arrow represents how technology is appropriated during the short period of most disasters. The framework guides our case analysis of risk mitigation in virtual communities in times of disaster.

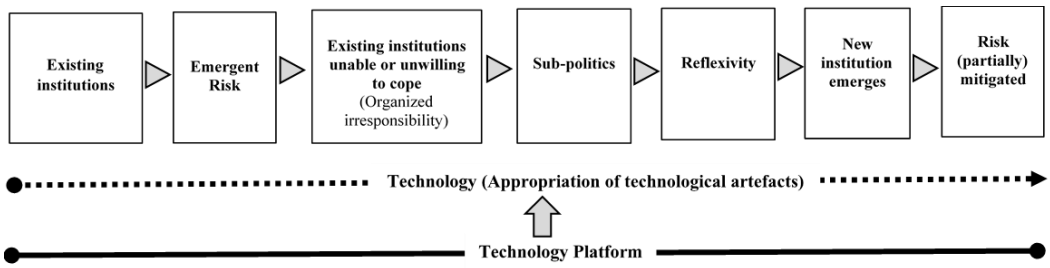

Figure 3. 2 A framework of risk mitigation in virtual communities

3.3 Methodology

We conducted an in-depth interpretive case study of a virtual community, the r/Houston Reddit group, looking at how this community mitigated the risks associated with Hurricane Harvey in 2017 (Klein & Myers, 1999; Walsham, 1995). On August 25, 2017, Hurricane Harvey made landfall near Corpus Christi, Texas with 130 mph winds. Later, Harvey moved slowly inland towards Houston where it remained for four days and caused extreme widespread flooding. Figure 3.3 shows a map and the timeline of Hurricane Harvey's progress. Substantial virtual community activity arose during the hurricane. Unfortunately, the official emergency number, 911, was overloaded and victims turned to virtual communities to request help (Luna & Pennock, 2018).

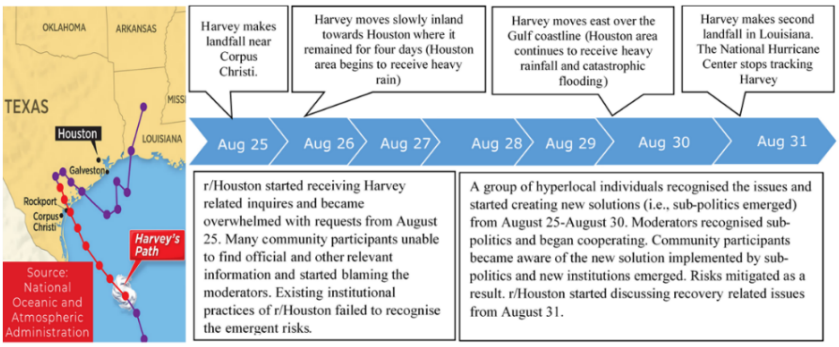

Figure 3. 3 Hurricane Harvey Timeline

3.3.1 Case Selection

We chose the r/Houston virtual community on Reddit as our case site for three reasons. First, this community focuses on local issues, people, and events pertinent to the Houston area.

Hence, the case site provided an opportunity to explore our research question in the context of the Hurricane Harvey disaster.

Second, we know substantial virtual community activity arose during the hurricane. The r/Houston community was not designed for disaster response, but members were highly active during Hurricane Harvey. Table 3.1 summarizes the activity level of the community both before and during the disaster. Critical to our research context, this community allows open and anonymous participation (i.e., anyone can participate). Therefore, information overload, overlap, falsehoods, and socially undesirable behaviours were present during the hurricane, again aligning with our research question. For example, we discovered that there were rumours of a shark swimming on the freeway and of the city of Houston checking immigration documents at shelters, deterring immigrants from seeking help.

Case Site (r/Houston Subreddit)	Before (Aug 11- Aug 24, 2017)	During (Aug 25- Aug 31, 2017)
Total number of threads created	1024	5315
Total number of comments made	19986	99078
Average # of threads created per day	73	759
Average # of comments posted per day	1427	14154

Table 3. 1 Summary of r/Houston activity level

Third, this community was active for at least five years before Hurricane Harvey hit Houston. Therefore, there were existing institutional practices including an established leadership structure (i.e., appointed moderators). Hence, it was possible to explore how existing institutional practices associated with this virtual community changed in order to manage the emergent risks associated with disaster information dissemination.

3.3.2 Data Sources

We used community-generated archival data in Reddit as the principal data source. Reddit is a social news aggregation, web content rating, and discussion platform of self-governed virtual communities.

Reddit was an ideal platform to study for four reasons. First, most other research studies have focused on virtual community platforms like Twitter (e.g., Kapoor et al., 2018; Oh et al., 2013; Starbird & Palen, 2011; Wyk & Starbird, 2020), where communities and topics are intermingled across the platform. It is thus difficult to ensure one has obtained all relevant content pertaining to a particular event (e.g., a natural disaster). By contrast, Reddit naturally divides itself into "subreddits" (i.e., defined subcommunities that focus on specific interests) (Buyukozturk, Gaulden, & Dowd-Arrow, 2018), which allowed us to focus on the specific community of people engaged in surviving Hurricane Harvey. Second, Reddit provides much richer content than other platforms that apply restrictions on content length such as Twitter (Stoffel, Jaeckle, & Keim, 2014). Third, Reddit data is open and archived. It is, therefore, relatively easy to trace the evolution of a conversation to identify where risky behaviours (e.g., spreading falsehoods, irrelevant contents) began on the virtual community, and how others responded. Fourth, it is possible for others to validate our data sources because they are publicly available (Miles & Huberman, 1994).

Figure 3.4 presents the schematic structure of the virtual communities (subreddit) and illustrates a thread (discussion tree) in r/Houston, composed of nested comments. The threaded discussion starts with an initial post (i.e., the first comment by original poster) followed by further comments replying to it. The discussion follows a tree structure where members may reply to the initial post or comments.

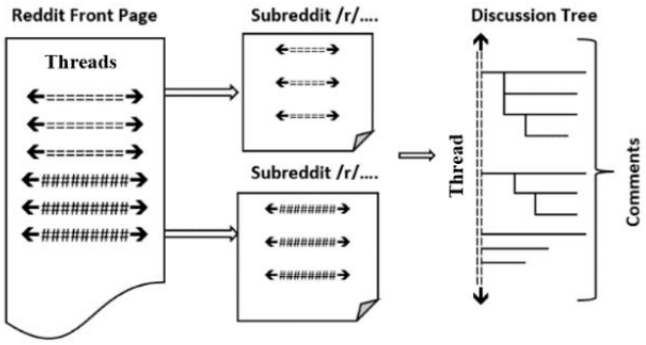

Figure 3. 4 Schematic structure of virtual communities (subreddits) on Reddit

3.3.3 Data Collection

We collected digital trace data (i.e., digitally recorded and time-stamped logs of activities and events) on Reddit. Digital trace data provides relatively precise and voluminous data on actions and events and hence is useful for theorizing about processual phenomena (Pentland, Recker, Wolf, & Wyner, 2020). We first collected all threads that were created around the time of Hurricane Harvey from the selected case site (see Table 1 for details). These were principally extracted using the Reddit search tool. However, the Reddit search tool restricts the amount of data one can retrieve in one query to 1000 threads. Therefore, we also used the publicly available data from Reddit archived on Google Big Query. We collected threads in the two weeks before the hurricane (August 11- August 24, 2017) and during the hurricane (August 25- August 31, 2017). We checked (by extracting and reading the threads) and found that no threads about the hurricane occurred two weeks prior to August 25.

Data from the two weeks before the hurricane (August 11- August 24, 2017) provided a baseline observation of the selected case site to understand their existing institutional practices. This study focuses on how virtual communities can mitigate emergent risks to effectively disseminate trusted hyperlocal information during a disaster. Therefore, the focus of our analysis was the 5315 threads containing 99078 comments associated with Hurricane Harvey created during the hurricane (August 25- August 31, 2017).

3.3.4 Data Analysis

We began by analysing the data iteratively, alternating between open coding and investigation of theories that might fit the emerging interpretation. Subsequently we found risk society theory (Beck, 1992; Beck et al., 1994) provided rich insights and hence we used this theory as a lens to conduct further coding. In our coding, we observed that the use of the technology platform (i.e., Reddit) enabled and constrained the dissemination of disaster information. For example, during the disaster, moderators used “highlighting” features to make

important information prominent. As risk society theory does not emphasise the role of technology, we added codes to describe the specific enabling and constraining features of the technology platform. We summarise the final codes applied in Table 3.2 below. The risk society codes were applied to the threads in the following way:

- *Existing institutions, emergent risk and organized irresponsibility:* We first attempted to identify *emergent risk*, defined as any activity of community participants or event that led to negative consequences. For example, a community member asked for emergency numbers and expressed frustration at not finding them easily. The community member then complained about the subreddit not being useful. We then attempted to identify how the existing institutions failed to respond to this emergent risk. We also wanted to find out why they were unwilling or unable to cope with the emergent risk (i.e., *organized irresponsibility*).
- *Sub-politics:* We then followed the thread to explore further evidence of dissatisfaction (by the original poster or others) and/or proposed new solutions to cope with emergent risk. For example, other community members echoed the original person's frustration at not finding the emergency numbers. Soon afterwards, someone suggested compiling all emergency numbers into a single thread. Hence we also explored how technology (i.e., appropriation of technological artefacts) was applied in *sub-politics*. For example, following the suggestion above, moderators compiled the emergency numbers into a thread and stickied the thread (i.e., permanently placed the thread on top of the pile of other threads to ensure heightened visibility), thereby enabling users of the subreddit to easily find emergency numbers.
- *Reflexivity:* Finally, we attempted to identify how information seekers acted towards the sub-politics (*reflexivity*). We checked whether the community members conferred or resisted the new solutions. For example, community members started following the

thread that was compiled earlier to find emergency numbers. We further observed outcomes of the new solutions proposed by the sub-politics (i.e., new institutional practices/technology emerged and succeeded or failed to mitigate emergent risks). For example, expressions of gratitude suggested the new solutions were now institutionalized.

Codes	Description
Initial response	
Emergent risk	Observed by the activity of a community participant or any event that led to negative consequences.
Existing institutions	The current practices to cope with emergent risk.
Organized irresponsibility	The unwillingness or inability of existing institutions cope with emergent risk.
Sub-politics	
Negative reaction with existing institutions	Observed by a negative emotion expressed by community members.
Proposed new solution	Action by a community member to propose new solution to cope with emergent risk.
Implement the proposed solution	Action by a community member to implement the proposed solution to cope with emergent risk.
Reflexivity	
Reaction towards the implemented solution (i.e. emergence of new institution/technology)	Community members desire to use or resist the proposed solution.
Outcome of the new solution	Indications that emergent risk is mitigated.
Technology	
Technology enactment	The appropriation of different features (i.e., technological artefacts) of the Reddit platform that facilitated or constrained the formation of a new institution

Table 3. 2 Summary of Interpretive codes

After our theoretical coding, we compared the process flows (as captured by the codes) across the threads. We observed common patterns across the sub-politics (i.e., how new institutions emerged). Specifically, we observed the following patterns: creating a controlled

information hub, permitting identity disclosure, and granting temporary emergent hyperlocal leadership. We then compared these patterns with the established literature. To our surprise, these patterns seemed to contradict the recommendations of previous IS research literature. We then returned to our data to determine whether there was evidence contradicting these discovered patterns. Finding none, these common patterns became the central theme of this paper. The four vignettes discussed below illustrate how risk was associated with information dissemination and how new institutional practices emerged to cope with these risks.

3.4 Findings

Vignette 1: The Need for Collated Authoritative Information

Existing institutions, emergent risk and organized irresponsibility: During Hurricane Harvey, multiple authoritative sources (e.g., the National Weather Service Houston/Galveston station, the Houston Police, National Hurricane Centre, News broadcasting channels, Mayor of Houston) issued important information such as weather updates, warnings, advice on how to use water and so forth. However, there was no centralized information hub that compiled all the authoritative information into a single place. People busy coping with the disaster often were unable to collate this information for their own use. Initially r/Houston Houstonians sought authoritative information from traditional collation services. However, they found that these services were not valuable, because they targeted a multitude of audiences, not just the disaster-stricken community. The quote below is from a Houstonian who tried looking for information on a virtual news community:

"The /r/news Livethread was hot garbage. What Houstonians need are other locals who actually know what's going on. Not non-locals (who don't know shit about what's going on) tossing blame at this official and that official."

Hence, users turned to the r/Houston subreddit to find authoritative information pertinent to the Houston area. Although a few users circulated authoritative information, this

was scattered across multiple threads which made it difficult to locate specific information. For instance, one person was looking for information about road closures, openings and water levels.

"My 62 year old mom needs me to come to Houston and take her to a hospital for hip pain ASAP. How will I know when it's safe to drive there? Where do I get official information about road closures/openings and water levels?"

One technology feature of the Reddit platform is that users can insert hyperlinks (e.g., tweets by the national hurricane centre) into a comment to direct other users to important information. However, this way of obtaining information is time consuming because the user must manually click each hyperlink which then redirects to the original source. If one is trying to obtain information from multiple sources (e.g., information about road closures and water levels), the cost in terms of time can be quite high. The existing moderators demonstrated organized irresponsibility by accepting the technological limitations of hyperlinks without seeking an alternative solution.

Sub-politics: People complained about the r/Houston subreddit and viewed it as inadequate.

"It's almost like half of this sub has been shitposting, no official information. And this is 100% useless."

To handle this issue, some Houstonians in the r/Houson subreddit began aggregating information from authoritative sources relevant to Houston into a single "livethread." A livethread is a collaborative webpage provided by the Reddit platform designed for real-time updates where multiple contributors can add short snippets of information (e.g., hyperlinks). A livethread must be created as a separate group outside of the subreddit. The livethread is then populated with hyperlinks to information. When the livethread is linked to a Reddit subcommunity (e.g., r/Houston), it pulls information from the hyperlinks into the livethread page and presents information in reverse chronological order. Hence, viewers of the livethread do not have to click on the links to obtain information. The livethread was configured with a

main panel where the hyperlinks resided and a sidepanel. Houstonians could now visit the livethread as a one-stop source of all relevant information about Hurricane Harvey pertinent to Houston.

Because the livethread is initially created outside of the subreddit, the livethread owner sets his or her own security configuration (i.e., read/write permission). In this case, the livethread owner granted permission to a small set of volunteers to modify the livethread, and public access to everyone to read the livethread. Once created, a livethread (i.e., URL of the webpage) must be submitted to a subreddit and requires consent of a moderator to make it visible to the community. The livethread owner submitted the URL to r/Houston and moderator consent was readily given.

"Further thanks to the /r/houston moderation team for enabling this livethread in the first place."

A team of volunteers (i.e., individuals living in Houston) was recruited to maintain the livethread. The team went to official sources and identified information from official sources relevant to r/Houston. The consensus among the team was to focus specifically on the Houston metro area.

"We've decided to keep this Live thread going to keep it aligned with the Houston Metro area as best as we can" "We'll continue here [livethread] and make sure everyone is up to date here on all the ongoings as they affect Houston."

The side panel was populated with links to information deemed most pertinent to the Houston community such as a checklist of what to prepare for in a hurricane by the Red Cross, a link to a flood warning system map from the weather service center, and a link to a power outage tracker for Houston.

"For those of you still here, thanks for tuning in! I'm gonna do my best to keep this updated with information that will impact the Houston area. I've been updating the resources sidebar with additional links so please check that as well."

Reflexivity: The r/Houston community now followed this livethread, as illustrated by the following comment. They obtained authoritative information pertinent to the Houston area from the livethread.

"I saw a comment or tweet in the livethread last night saying that we should reduce anything that puts water down the drain. This was due to a maxed out sewer treatment capacity."

Users also showed their gratitude to the team of volunteers who contributed to the livethread.

"I want to give a shout out to [the livethread creator- name withheld], I saw him posting so many updates on the live thread. And any of the others that were working tirelessly on it. Good job yall. The things you write here have an impact far beyond reddit. They are passed along to friends in text, phone calls to aunts, and tweets to the area."

"Not to mention the numerous updates from the mayor that I wouldn't have seen otherwise. It meant a lot, thanks for your work."

Vignette 2: Centralizing Community Conversation

Existing institutions, emergent risk and organized irresponsibility: During the hurricane people actively sought both hyperlocal and non-hyperlocal information from the r/Houston community. They created individual threads or commented on existing threads to exchange information. Information exchanged included the current hurricane situation, the availability of drinking water, general advice, as well as volunteer opportunities such as where to donate food and clothes.

"Hey guys, just wondering if there is a running list of stores that are open for groceries or food in general. I haven't been able to go out and search as our streets are flooded, and I'm sure other people are curious about the closures around them since some may not have prepared as extensively as they might have."

"Holy hell. I'm so sorry to hear your [dad's home] is completely flooded. My husband should have Friday off to help with debris clean up. Keep in touch and let me know if y'all need anything?"

People also attempted to signal their concern by posting (i.e., by creating individual threads) short messages of assurance like 'Stay safe.' However, the generation of multiple

requests for information, offers of service, and messages of assurance created a tragedy of the commons effect where the multitude of generated threads made it difficult to find information. This was confounded by the large number of threads asking for the same information. Others would respond to these threads with conflicting or erroneous information. For example, one person created an individual thread asking if someone needed a boat for rescue but did not get any replies, even though there were people in need of such assistance.

"My brother has a boat and is ready to pick people up! Where can we find a list of people that currently need help?"

People also created individual threads or commented on the existing one to find listed information (e.g, list of emergency numbers; list of pharmacies that were either open or inoperable; list of open shelters; list of places seeking volunteers) and started blaming the moderators for not acting accordingly. Although some of this information (e.g., emergency number) was already available in multiple hyperlinks inside the livethread, people wanted these to be compiled into a separate single thread.

"Why in the world are all the known emergency numbers not pinned in this subreddit? Can we compile all known emergency numbers in one [thread] and pin it already? Do we have mods on this subreddit? The community has been keeping everyone informed."

One person could not find a list of open places that someone had shared earlier.

"Does anyone have a list of places open in Montrose? I saw someone post a map yesterday, but can't find it now. I want to leave the house and see some other people."

While the r/Houston community wanted a better way to find important information, moderators demonstrated organized irresponsibility by arguing the constraints of the technology platform precluded them from organizing the information in a better way.

"Reddit only allows for two stickied [pinned] posts. Complain to the [Reddit] admins, not the moderators."

Sub-politics: The default configuration on Reddit (which r/Houston used) sorts threads based on popularity (in Reddit, called upvoting- a feature similar to 'likes' in Facebook). Upvoting is

a way to indicate support for posted information. Popular threads appear at the top of the pile. The creator of the livethread posted a thread asking the moderators to create a special single thread placed on top of the pile of threads (called a megathread) so all information would be collated in a central place. Creating such a megathread required moderator permission. Multiple people upvoted this request, which meant this thread continued to appear at the top of the thread pile. The moderators agreed to create the megathread.

The initial megathread was not very successful. Its title ("Yeah, this weekend is looking wet for Texas") did not clearly articulate that it was a megathread. The creator of the livethread highlighted the problem. As both moderators were outside Houston during the storm, they granted the creator of the livethread temporary moderator status and he began creating megathreads.

Every megathread on Reddit has particular characteristics. First, each must be created by a moderator. Every megathread also has a title, a description box, purportedly to describe what the megathread is about, and an initial post (i.e., the first comment).

One technology feature available to moderators is the ability to "sticky" threads or comments within a thread. A sticky thread appears at the top of a pile of threads regardless of its votes and time since posting. However, a subreddit can only have two stickies (i.e., either two threads or a thread and a comment within the thread) at any one time. The livethread creator created megathreads for the first two days of Hurricane Harvey. He then stickied the megathread for that specific day (unstickying the previous day's thread). Each megathread was titled Hurricane Harvey Megathread (Day X). The description box was used to link to the livethread. Thus, anyone accessing the megathread would have pertinent information relevant to that particular day at their fingertips. He also stickied the initial post (i.e., the first comment) which contained the current up-to-date emergency instructions issued by authorities such that it always appeared on top of the megathread. The livethread creator also added further

information in the initial post (i.e., the first comment) such as emergency numbers, a list of open shelters, evacuation routes, and a link to an annotated Google maps with locations of important resources.

The moderation team returned to Houston on day 3 and took over creation of the megathreads. They copied the practice created by the livethread creator until the hurricane was over (i.e., the two stickies would be for the current day's megathread and the first comment within the megathread containing the public service announcement). The moderators also changed the technology for identifying which comments would be on top of the megathread. Recall that by default, the ratio of upvotes to downvotes is used to sort comments. During Hurricane Harvey, moderators switched this so new comments were placed on top of the comments in the megathread. Thus, people could see new information first.

"People vote for visibility in situations as this way important information goes to the top." "Not true. In this thread, sorting is done so that people see newer stuff first. Downvotes, upvotes don't matter much in this instance."

The Reddit technology platform allows one to apply different font transformations to text. It also allows moderators to edit others' comments. Moderators went through comments in the megathread and highlighted in green what they perceived as important information. People scanning through the voluminous comments in the megathread could thus quickly pick out what was important.

"We have 2 spots to sticky things, that's it and there's a lot of stuff that would be great as stickies. That's why we're highlighting important lists green."

Reflexivity: People recognized the megathreads as an effective solution and used them as a primary source of information. For example, they obtained near-real time information on water levels, road closures and open stores.

"This subreddit and these megathreads specifically have been a tremendous help not only for me, but for other guests in the hotel as well since it allows me to see basically in real time what areas are clear, what roads and stores are open, and so on, because despite the unprecedented storm, people still are foolish enough to want to venture out for whatever reasons."

Another community member appreciated the efforts and commented that megathreads helped to keep themselves, their family and friends safe.

"Thanks for your help running the megathread. As a Houstonian who was recently transplanted to Austin, your threads made sure that I could check up on my family and friends as they evaded hell and high water and keep them up to date if they were missing info."

Vignette 3: Disclosing Personal Information

Existing institutions, emergent risk and organized irresponsibility: The default setting applied to most subreddits available on the Reddit technology platform is anonymity. This setting enables users of the r/Houston subreddit to maintain their privacy.

"I'm going to delete my initial comment because, you know, personal information and the internet."

Before the hurricane, Moderators enforced the practice of maintaining one's privacy by deleting any self-identifying comments posted by users. However, anonymity creates a number of problems, especially during a disaster. First, people are more likely to make insensitive statements if they are anonymous (Chen, Li, Hu, & Li, 2016). For example, the following comment appeared in r/Houston:

"It's better if they die. Why should I have to treat a homeless patient who can't even swim? And not even get paid for it? If you care so much, take them into your home. Oh, don't want to? I bet you wouldn't even open the door if they were banging on your door. You hypocrite."

Second, people can spread fake news without fear of repercussion. Such fake news on r/Houston included doctored photos of a shark swimming down the (flooded) freeway, claims the city of Houston was checking immigration documents at shelters and that:

"The city of Houston is shutting down water service."

The presence of callous comments and fake news creates the third problem with anonymity. When people post genuine information, others do not know who or what to believe. For example, a meteorologist from Virginia shared real-time weather updates and tried to explain some disaster models to the r/Houston community. Because people could not verify

the identity of the meteorologist they questioned the veracity of his information. The meteorologist then had to explain the information source.

"We are relaying data generated from weather modeling to raise awareness. I'm not making these weather maps up. Myself and everyone who follows these hope they bust, but the reality is people should pay attention when the ECWMF (Euro) makes such predictions."

Fourth, it is hard to seek help while anonymous. Donations need to be routed to a target, and rescuers need to go to an address to rescue someone. Moderators demonstrated organized irresponsibility by following community rules strictly prohibiting participants from posting personal information.

Sub-politics: Given the problems with anonymity, a consensus emerged that the anonymity practice should be relaxed, and people should be able to reveal information about themselves if necessary. The revelation of one's identity might also help convince others of the veracity of the information.

The Reddit technology platform offers a feature called "user flair" by which moderators can label particular individuals as belonging to a group. When a person adds a comment to a thread, the username and any associated flairs are attached to the comment. People requested that moderators create new flairs to indicate the location of help seekers or signal the professional identity of information providers.

"If you are on desktop and go to the subreddit you can request a flair for your area."

The moderators agreed to create such flairs. Below are some examples of the flairs moderators created. Montrose is a Houston neighbourhood, commonly called the "Heart of Houston."

Posted by u/username/ Former NRL Meteorologist ⟸ *flair*

Posted by u/username/ Montrose ⟸ *flair*

The rules on identity provision were also relaxed. During the disaster, people could reveal personal information such as their address.

"I have a friend in Kingwood who list (sp) power a day ago, and is out of contact... may need a rescue... does anyone know the situation there? Address is [house address]."

Reflexivity: The community recognized the value of the flairs during the disaster and asked others to obtain one.

"People, make sure you have flair…. We need to know where you are".

Some people started asking others to share their location for rescue purposes and for sending donations or relief directly to the victims.

"Can you share your address here or PM it to someone? They can post your location to the various rescue group pages on Facebook and get someone to your rescue hopefully!"

The introduction of flairs reduced anonymity and created new institutional practices within the r/Houston community. A trust premium was awarded to people who revealed themselves or could be identified as living in Houston or to those who were identified as having a disaster-relevant profession.

"I relied on you guys in throughout, and you [locals] gave reliable, on the ground, information, for all of us struggling to figure out which areas were about to get flooded. r/houston = best coverage of this whole shitshow!"

Vignette 4: Regulating Community Conversation

Existing institutions, emergent risk and organized irresponsibility: During the hurricane, many people started following the r/Houston subreddit for the first time, but many of these were not from Houston. Before the hurricane, the r/Houston subreddit welcomed all kinds of discussion related to Houston including making claims without supporting evidence. However, many participants started discussing irrelevant issues (e.g., politics), trolling and sharing unreliable information during the hurricane (including in the megathreads). Many community members found this kind of conversation inappropriate and questioned the veracity of given information. For example, a community participant commented:

"What is your "reliable source"? Clear Lake City Water Authority issued a statement that rumors on social media that the water supply is threatened are false."

Posting irrelevant and unreliable information led to wrong user actions (e.g., some legitimate information was down-voted). Rumours were rife. For example, some community participants commented that they had "heard" from their friends that some roads were dry whereas these were actually flooded and vice versa. The moderators demonstrated organized irresponsibility by allowing irrelevant and unreliable content to be shared in the community.

Sub-politics: People continued showing their frustration towards moderators for inactive patrolling.

"Well this sub was helpful for a while. Now it's a bunch of political shitposting by outsiders. The mods always sucked on this sub. Stay safe."

To combat the spread of conflicting and erroneous information, people began suggesting any informational comment be backed by evidence (e.g., an image or a video) or by a link to official sources.

"Yeah, reports from reliable sources are good to share. Rumours and news circulating solely on social media are spreading a lot of unnecessary distress."

Users (both local and hyperlocal individuals) began to use Reddit's voting feature (i.e., up-vote or down-vote) to indicate which information was useful. A norm emerged where evidence-based informational comments were given many upvotes, while those without evidence were down-voted.

"I repeat stop asking questions here there is only two acceptable comments in this thread that won't get you downvoted: 1. Picture/description of where water is. 2. Some sort of caring "stay safe friends" comment"

Users started reporting irrelevant content using the "Report" button. If content is repeatedly reported it is usually reviewed by the subreddit moderators. Moderators now began to recognize the need for active patrolling. They started policing the megathreads by removing inflammatory, irrelevant comments and fake news. They advised people to redirect their

questions to the appropriate megathread and also banned users who tried to propagate rumors and fake news.

"Hey /r/houston, we've been cleaning out a lot of stuff from the subreddit to try to keep more important info at the front page… General questions are still best posted in the megathread discussion! It's super active and sorted by new so your stuff gets seen."

Reflexivity: People started providing evidence such as pictures while seeking help or giving information. Users found this evidence useful and appreciated those who provided it:

"Thank you for actually posting evidence instead of telling people to go find it."

The active patrolling of the megathreads meant irrelevant contents (e.g., political statements) and socially unacceptable behavior (e.g., trolling) in the megathreads was greatly reduced. Users appreciated the efforts made by the moderators for keeping relevant information flowing.

"The mods have and still are doing an absolutely amazing job and I can't thank them enough who did all of the pertinent information upkeep."

3.5 Discussion

Previous research has demonstrated that information seeking behaviour during times of disaster follows a particular set pattern. People initially seek information through the most common channels (e.g., phone calls, text messages, etc.) used by their own social networks (Palen & Liu, 2007). If unsuccessful, they then turn to authoritative sources (e.g., emergency management agency, traditional media outlets such as radio, newspaper or television) to obtain information (Simon, Goldberg, & Adini, 2015; Stiegler, Tilley, & Parveen, 2011).

Authoritative sources generate substantial information for the public, such as emergency alerts, disaster maps, or do's and don'ts during a disaster. However, information generated from authoritative sources is typically generic (e.g., go to your nearest shelter, request rescue by calling 911). During a disaster people often seek hyperlocal information, i.e., information specifically relevant to a particular narrow geographic locale, rather than

nonspecific information pertinent to the entire disaster-affected area. For example, an emergency management centre could issue emergency alerts and ask people to evacuate to their nearest shelter. But which is the nearest safe shelter? People coping with a disaster are interested in identifying the location of and exact route to the nearest available shelter. Road conditions, the presence of a gas leak, the capacity at each shelter, etc. might mean the nearest available shelter is not necessarily the nearest shelter geographically. Transforming trusted authoritative information to fit the local context requires local people to adapt information. Locals are thus the true "first responders" who witness the disaster directly and convey information to others (Simon et al., 2015). Local people can generate their own hyperlocal information while at the same time transforming authoritative information into relevant hyperlocal information.

Our findings suggest one approach to generating hyperlocal information and transforming trusted authoritative information is for a virtual community to create three kinds of institutions: (1) a controlled information hub, (2) promoting identity revelation and (3) temporary emergent hyperlocal leadership. A summary of our findings is presented in Table 3.3. Table 3.4 shows how our findings contradict prior studies. Please note that these findings are relevant to disaster situations only, and we do not claim that our findings relate to non-disaster situations.

Necessary institutions	**How do they work**
A controlled information hub	(1) Centralization of information so the information is easy to find. (2) Curation of information to reduce search cost. (3) Providing supporting evidence so information can be trusted.
Promoting identity revelation	(1) Allowing disclosure of personal information so people can get desired social support (e.g., rescue, donations, etc.). (2) Facilitating identity signaling that reveals hyperlocality and professional status, thereby leading to higher trust in the information provided.
Temporary emergent hyperlocal leadership	(1) Recognizing emergent hyperlocal leadership. (2) Cooperating with emergent hyperlocal leaders for effective disaster response.

Table 3. 3 Summary of findings

Prior studies	Our findings	Evidence
Virtual community should be open and allow free participation (Park & Johnston, 2017; Pi, Chou, & Liao, 2013; Rheingold, 1993; Whittaker, McLennan, & Handmer, 2015; Yu, Lu, & Liu, 2010; Zhiyi, Hamalainen, & Zhangxi, 2008)	Virtual community should be controlled and biased towards hyperlocal individuals during times of disaster. This helps to generate relevant and useful authoritative and hyperlocal information.	Vignette 1: Authoritative information was collated from multiple sources and screened by a group of hyperlocal individuals. They maintained relevancy of the information. Vignette 4: Moderators censored falsehoods, irrelevant content, and banned unwanted users to keep relevant, trusted information flowing. Both local and hyperlocal individuals reported and down-voted falsehoods and inflammatory contents.
Anonymity protects individuals from socially undesirable behaviour in virtual communities (e.g., abuse of personal information), improves group performance and freedom of self-expression, fosters community identity and strong group norms, builds trust and enhances social ties (Connolly, Jessup, & Valacich, 1990; Hoffman, Novak, & Peralta, 1999; Mkono, 2018; Prakasam & Huxtable-Thomas, 2020; Rainie, Kiesler, Kang, & Madden, 2013; Ren et al., 2012; Shanley, Burns, Bastian, & Robson, 2013; Shiue, Chiu, & Chang, 2010)	Anonymity hinders individuals from receiving social and informational support at their specific location during a disaster. Therefore, a virtual community should promote identity revelation.	Vignette 2: Hyperlocal individuals started seeking help without disclosing their personal information. It was thus difficult to know where to send help. Vignette 3: Moderator relaxes anonymity rules. Hyperlocal individuals started disclosing their personal information (e.g., address) and professional identity to seek and provide social and informational support.
Leadership in virtual communities emerges through open interactions (Johnson, Safadi, & Faraj, 2015; Kilgo et al., 2016). The geographical location of participants does not matter (Guinalíu & Jordán, 2016; Ward, 1999; Warshaw, Whittaker, Matthews, & Smith, 2016).	Virtual community leadership should be (at least temporarily) situated in a hyperlocal context in times of disaster. The situatedness of leadership helps to address local needs.	Vignette 1: A group of hyperlocal individuals from the r/Houston community monitored the on the ground situation, acknowledged the extent of the disaster, and created an appropriate information hub. Vignette 2: Moderators were unavailable during the anticipatory period of the hurricane. Therefore the livethread creator took responsibility for the creation of megathreads.

Table 3. 4 Overview of contribution of this study

(1) A controlled information hub: Previous IS research on virtual communities suggests they should be open and allow free participation to generate public information and discourse (Cothrel & Williams, 1999; Pi et al., 2013; Rheingold, 1993; Yu et al., 2010; Zhiyi et al., 2008). Recent studies on virtual communities further supports the idea of open collaboration among virtual volunteers during disasters (Park & Johnston, 2017; Whittaker et al., 2015). However, our findings suggest that open, uninterrupted participation is not in the best interests of the people who lives are threatened by a disaster.

Prior to a disaster, the typical virtual community has individuals with diverse needs and interests, and it is important to support a large subset of those needs for the virtual community to thrive. As a result, openness is likely the best policy. However, during times of disaster, the needs and interests of virtual community members narrow tremendously - most individuals need rescue, basic necessities, and trusted sources of information. Furthermore, these needs and interests become hyperlocal - people need rescue or emergency supplies to be provided at a specific location. In non-disaster periods, a virtual community values large quantities of information, where each piece of information is typically consumed by a relatively small pool of individuals. In contrast, in times of disaster, only a relatively small set of information is considered valuable, and that small set of information must reach many people. Indeed, during this period, peoples' tolerance for information that is not immediately relevant to their situation is reduced (witness the resistance to political dialogue in vignette 4). Furthermore, much of the information of importance is generated by a small set of community members - people who are actually on site (i.e., hyperlocal individuals).

The changed needs of the virtual community suggest a radically different set of institutional arrangements are needed during a disaster. These arrangements should (1) promote centralization of information so it is easy to find, (2) provide supporting evidence so

information can be trusted, and (3) provide for the curation of information. This reduces the amount of information for disaster victims thereby reducing search cost.

Vignettes 1 and 2 highlight the importance of information centralization. In vignette 1, there was no centralized information distributor and people had to refer to other sources such as multiple authoritative sources and other virtual communities. Obtaining information during this period was time-expensive. Therefore, a set of local volunteers formed a group and aggregated authoritative information in a single thread where posting permission was restricted to this set of volunteers. In vignette 2, people kept posting multiple requests in various threads, which made it difficult for others to find relevant hyperlocal information easily. Hence, a special thread (a megathread) was created for each day of the disaster, and people were redirected from other threads to post all queries in this thread. Collated authoritative information was also integrated with this special thread so people could simultaneously read and post.

Mechanisms also need to exist to authenticate and identify relevant information. Vignette 3 presents a mechanism of authentication where user flairs were introduced to identify particular individuals as possessing trusted information (e.g., weather interpretations, situations at a hyperlocal site). In vignette 4, practices arose to authenticate specific pieces of information (e.g., evidence needed to be provided in any informational post) and curate the information during a disaster (e.g., irrelevant and false information was regularly downvoted by community members and removed by moderators).

(2) Promoting identity revelation: Anonymity has long been recognized as a key hallmark of virtual communities (Connolly et al., 1990; Yoon & Rolland, 2012). Indeed, many studies advocate and recognize its importance for ensuring safety against physical threats (e.g., robbery) (Park & Johnston, 2017; Shanley et al., 2013), cyber-harassment, abuse of personal information (Chen et al., 2016; Rainie et al., 2013), social loafing (Shiue et al., 2010), trolling,

flaming, and hate speech (Mkono, 2018). For example, cyber-harassment can lead to individuals leaving a community. Abuse of personal information can cause identity theft. However, our findings suggest that during times of disaster, anonymity is not always desirable. In times of disaster, knowing someone's physical location is critically important. Whereas being anonymous means you could be anywhere, revealing your identity proves that you are on the ground in a particular place.

Vignette 3 highlights how self-disclosure helped people receive tangible support (e.g., rescue). People requested rescue by posting their or others' personal information (e.g., address). Revealing one's identity also reduced scepticism and promoted the flow of valuable information. For instance, initially people did not believe the information provided by a meteorologist until his real-world occupation was revealed. In vignette 2, people wanted to know where to volunteer, and offered food as well as help to clean debris. Many people also wanted to send relief or donations directly to the victims rather than through humanitarian organizations such as the Red Cross.

Therefore, during a disaster, a virtual community should consider (1) allowing disclosure of personal information so people can get required support (e.g., rescue, donations, etc.), and (2) facilitate identity signaling, i.e., a demonstration of one's hyperlocality and/or professional status.

Vignette 3 shows that, before the disaster, posting personal information was strictly prohibited as it was against community rules and Reddit policy. Posting personal and confidential information led to people being banned and could result in account deletion. However, during the disaster, people revealed their physical location to obtain support. The r/Houston moderators relaxed rules on self-disclosure and allowed people to post personal information. Moderators also introduced several digital identifiers (e.g., flairs), and people started "wearing" them to reveal their location and areas of expertise.

(3) Temporary emergent hyperlocal leadership: Leadership becomes essential to mobilizing effective response in times of disaster (Comfort & Okada, 2013). Many studies have paid attention to the role of leadership and open collaboration in virtual communities (Johnson et al., 2015; Lee, Yang, Hsu, & Wang, 2019; O'Mahony & Ferraro, 2007; Panteli & Sivunen, 2019). Leadership in virtual communities can either be appointed or emergent in nature (Johnson et al., 2015; Wickham & Walther, 2007). Since virtual communities support the idea of voluntary and open participation (Lu & Yang, 2011), leadership in virtual communities tends to emerge spontaneously through open interactions (Johnson et al., 2015; Kilgo et al., 2016). Normally, the geographical dispersion of community leaders does not matter. As a result, the ubiquity of leadership is likely the most commonly observed practice available in virtual communities. For example, project leaders of open source communities (e.g., Wikipedia) can lead a community from anywhere in the world. Similarly, Warshaw et al., (2016) reported that leaders can emerge in virtual communities spontaneously regardless of their geographical location.

However, our findings suggest that ubiquitous leadership is not desirable in virtual communities during times of disaster; rather, leadership should be, at least temporarily, situated in a hyperlocal context. During a disaster, assessing local needs, securing appropriate resources, and relaying information to those involved is not possible without being physically located in the affected area.

Vignettes 1 and 2 describe how people needed street-level assessment during the hurricane. For example, they sought information about the water level in a specific street and wanted the projections for the next few days. They wanted to know where to volunteer and donate resources. Many affected individuals were interested to know where and how they could reach official responders. A group of hyperlocal individuals from the r/Houston community started to take public responsibility, monitoring the on the ground situation, and created the

appropriate information structure (i.e., a controlled information hub) that served as one of the main information sources for public consumption.

Indeed, not being hyperlocal means one does not understand the situation on the ground. The megathread that was created during the hurricane was only successful when a hyperlocal individual took over its management. The original megathread created by the moderators was wholly inappropriate. Our findings therefore suggest a virtual community needs to (1) recognize emergent hyperlocal leadership, and (2) cooperate with the emergent hyperlocal leaders for effective disaster response.

In vignette 1, the livethread creator recruited a group of hyperlocal individuals to transform, distribute, and translate trusted authoritative information to affected laypeople. The livethread creator also requested the moderator to make a livethread visible to the r/Houston community. The moderator recognized the value of the livethread to the community and gave immediate consent. In vignette 2, the moderators created a megathread upon request, and it was not very successful initially, but became successful when moderators granted the livethread creator temporary moderator status. This also enabled the livethread creator to ban users who were posting maliciously.

3.6 Conclusion

This study has examined how virtual communities can provide trusted hyperlocal information during a disaster. Addressing this problem is a challenge because virtual communities are usually open social systems that allow hundreds if not thousands of people to participate anonymously. Moreover, the geographic location of virtual community members typically does not matter. During a disaster, however, these very same features create additional risks for disaster victims. It can make it difficult for those whose lives might be at risk to find helpful, trusted information that is specific to their local area. Hence, this paper has focused on

how virtual communities can be used to provide trusted hyperlocal information during a disaster, while mitigating the risks.

We acknowledge limitations of our research. First, the problems we are addressing are not related to the disaster per se, but rather to ways people and institutions respond to disasters.

Second, ours is a single-depth case study focused on a specific disaster scenario (i.e., Hurricane Harvey). Therefore, our findings illustrate just one possible, effective response to a disaster; perhaps other responses could be just as if not more effective. Although we cannot generalize our findings to a population, like all qualitative studies we have generalized our findings to a theory, in our case that of the risk society. The proponents of this theory argue that contemporary society organizes in response to risk. We have shown that many of the risks that emerge during a disaster are not natural, but human generated. People organized themselves on the r/Houston subreddit in response to this risk.

A third limitation is that we collected our data from a single communication platform (i.e., Reddit). Other platforms may provide different features which could trigger the community to form new institutions. We thus encourage future research to investigate other communication platforms (e.g., Twitter, Facebook, Digg). We also acknowledge that our study only focuses on the disaster response period. However, institutions in virtual communities may evolve with time. As we mentioned earlier, the livethread, megathread and user flair practices have evolved in the r/Houston community.

Practical Implications

Our study has several practical implications for virtual community leaders, emergency authorities and system designers. It is well known that providing accurate, valid and timely information is key in effective disaster response (Kim, Bae, & Hastak, 2018; Tim et al., 2017). However, information overload and falsehoods are known impediments to effective virtual community-led disaster response (Hiltz & Plotnick, 2013; Luna & Pennock, 2018). Some

characteristics of traditional virtual communities like openness and anonymity actually magnify these impediments, thereby aggravating bad situations in times of disaster. Our study suggests that one approach virtual communities can employ to mitigate these issues is to incorporate the following five changes to their institutions when disasters arise:

First, virtual community leaders can centralise the flow of information. This makes it easier for both virtual community leaders and community members to process the information and extract the most salient information that is of the most benefit to disaster victims. They should actively curate information and keep important information visually on top of the community discussion board. Accordingly, it may be beneficial to reverse policies of openness during disasters. Virtual community leaders should only allow individuals who can provide relevant information to post. During times of disaster, people are overwhelmed with information and cannot easily find the information they can act upon.

Thus, in times of disaster, one potential key role of virtual community leaders is to develop new institutional practices that aggregate information from both authoritative and hyperlocal sources. In our study, hyperlocal volunteers aggregated authoritative information in a single thread and integrated this thread with the megathreads. This approach made information easily visible for community participants.

Second, during times of disaster, virtual community leaders might want to establish community norms that informational posts must be evidence-based. Fake information not only burdens emergency response but also leads to an increase in public anxiety. Allowing only trusted information to propagate reduces the amount and impact of fake information.

Third, virtual community leaders should reverse policies promoting anonymity during disasters. Virtual community leaders should allow people to disclose their identity and personal information. Our study suggests identity revelation can foster trust and encourage more reciprocal behaviours. It is also necessary if people need assistance. In our study moderators

relaxed anonymity rules, allowing people to disclose personal (e.g., address) and professional identity information. Community platforms should also include features (e.g., badge) signaling the identity of information providers.

Fourth, consonant with previous studies, ours shows the importance of emergent leadership. We found effective emergent leaders during a disaster were always hyperlocal individuals (i.e., people on the ground). Once identified, virtual community leaders should cooperate with them (i.e., creating a shared vision) and grant them power (e.g., endorse temporary moderator status). In our study, moderators granted power to the livethread creator (i.e., a hyperlocal individual) who took responsibility for the creation of megathreads. In times of disaster, it is therefore profitable for virtual community leaders to seek out emergent hyperlocal leaders. Community platforms should thus include features (e.g., frequency of interaction, location) to identify potential hyperlocal leaders and facilitate their contributions.

Lastly, our research suggests existing government and disaster-focused emergency organizations (e.g., incident management officials, law enforcement agencies) should actively collaborate with virtual communities. Official information should be made easily accessible to virtual communities e.g., perhaps through an open application programming interface (API). At the moment, such information is often only made available in difficult-to-process forms like web or twitter announcements. Disseminating such information in an API would make it easier for virtual communities and other frontline/first-responders sources to better respond in particular hyperlocal situations.

In summary, our case study of a virtual community during Hurricane Harvey has identified institutional practices that facilitate successful management of disaster information. We have shown that openness and anonymity are not appropriate in times of disaster. Instead, virtual communities should be more controlled, biased towards hyperlocal individuals, and

promote identity revelation. Also, virtual community leadership should be situated, at least temporarily, in the hyperlocal context.

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CHAPTER 4. THE ROLE OF DIVERSITY

Abstract

People visit virtual communities to find verifiable, accurate and reliable (VAR) information during disasters. Virtual communities are open spaces where people interact and share information. Current research argues diversity is vital for solving problems in virtual communities. However, we discovered that a more diverse virtual community can hinder problem-solving during a disaster. Falsehoods can spread more easily if a virtual community is diverse. We conducted an exploratory case study to better understand how and why. Using the lenses of organizational mindfulness/mindlessness and collective identity, our findings suggest the lack of goal consensus (i.e., diversity of goals) can hinder problem-solving during a disaster. One way of overcoming this is to enforce "transient partitioning" by identifying one goal and excluding users with other goals from the community.

4.1 Introduction

During extreme events (e.g., natural disaster, disease outbreak), informational needs change significantly due to high levels of fear and uncertainty (Jurgens & Helsloot, 2018). People need to obtain trusted information quickly as their lives might be in danger. They tend to seek this information from their fellow disaster victims on the ground as well as from official sources. Many people (both from disaster and non-disaster affected areas) turn to virtual communities to seek disaster related information (Lifang Li, Tian, Zhang, & Zhou, 2021; Tim, Pan, Ractham, & Kaewkitipong, 2017; Yuan, Li, Liu, Zhai, & Qi, 2021). However, as most virtual communities are not typically designed for disaster management (Nan & Lu, 2014; Qu, Wu, & Wang, 2009; Reuter & Kaufhold, 2018), it is possible for virtual communities to adversely affect disaster victims. This study extends our existing understanding of information dissemination in virtual communities during a disaster (e.g., Nan and Lu 2014; Qu et al. 2009).

One common problem with virtual community-led disaster response is the spread of falsehoods (e.g., fake news, misinformation, disinformation) (Luna & Pennock, 2018; Oh, Agrawal, & Rao, 2013; Silver & Matthews, 2017). These falsehoods can cause social problems (e.g., irrational panic buying or taking dangerous remedies) and put disaster victims at risk. For example, during Hurricane Irma in 2017, false claims arose on virtual communities that cracking windows a little at home could prevent them from breaking under wind pressure. More recently, an array of false information on COVID-19 has been posted online, such as the suggestion that vaccines can infect someone with the virus. Another problem is that an overabundance of information (which may or may not be false) can make it difficult for people to find reliable guidance when they need it (Scheufele, Hoffman, Neeley, & Reid, 2021). Counteracting the problems associated with the dissemination of non-useful disaster information (e.g., fake news, irrelevant information) requires collective problem-solving by the virtual community (Oh et al., 2013; Palen & Hughes, 2018; Silver & Matthews, 2017; Vieweg, Palen, Liu, Hughes, & Sutton, 2008).

Current research generally argues that diversity is vital for solving problems in virtual communities (Chu, 2009; Divakaran & Nørskov, 2016; Mačiulienė & Skaržauskienė, 2016; Ridings & Wasko, 2010; X. Yang, Li, & Huang, 2017). Diversity adds different perspectives on the same topic, which can lead to more effective discussions and increase the completeness of solutions (Endres & Chowdhury, 2013; Surowiecki, 2004). Encouraging diverse opinions along with free and open discussion may prevent groupthink and foster cohesive collective identity (Austin, 1997; Janis, 1982; Phan, Lee, Jang, & Gim, 2019; Polletta, 1998). Research furthermore suggests virtual communities allowing diverse opinions have a larger knowledge base for learning and decision making (Hara & Foon Hew, 2007).

However, in our study of a virtual community, we discovered the opposite. While diversity might be good under normal circumstances, during a disaster diversity can hinder problem-solving. Hence, this paper aims to answer the following research question:

How and why does diversity in a virtual community hinder the dissemination of verifiable, accurate and reliable information during a disaster?

This paper answers this question through an in-depth, exploratory cross-case analysis of a virtual community, the r/Houston Reddit group under two disaster scenarios: Hurricane Harvey, 2017 and the Great Texas Freeze Out, 2021. We argue one key inhibitor of the dissemination of verifiable, accurate and reliable information during a disaster is the *lack of goal consensus*. If there is a lack of goal consensus, diversity causes interpersonal conflict and the virtual community fails to develop optimal solutions to problems arising from the disaster. Our investigation suggests a possible solution is for the virtual community to enforce *transient partitioning* during the disaster – the moderation team identifies one goal and excludes users with other goals from the community (or at least prevents them from posting during the disaster).

The remainder of this paper proceeds as follows. The next section reviews the literature on virtual communities in disaster situations and the role of diversity in problem-solving in virtual communities. We then discuss our theoretical foundations of organizational mindfulness/mindlessness and collective identity. This is followed by our description of our research method. After the presentation of our findings, the final two sections are the discussion and conclusion.

4.2 Literature review

Virtual communities are open, voluntary participation systems that bring a diverse group of individuals from different geographic areas together (Faraj, von Krogh, Monteiro, & Lakhani, 2016; Lu & Yang, 2011). All types of virtual communities, including message boards,

chat rooms and social networking sites, encourage individuals to interact and build social relationships with acquaintances or strangers (Huang, Zhao, & Hu, 2019). Virtual communities are used for various purposes including knowledge-sharing, entertainment, health, crowdsourcing, business and marketing (Dissanayake & Sridhar Nerur, 2021; Faraj, Jarvenpaa, & Majchrzak, 2011; H.-W. Kim, Chan, & Kankanhalli, 2012; Wu & Bernardi, 2021).

The research literature argues that a key feature enabling virtual communities to thrive is diversity (e.g., Chu 2009; Kang et al. 2007). Diversity decreases prejudice and stereotypes among community members (Lee & Choi, 2017). Diversity also increases creativity in solving problems by encouraging broader perspectives and alternative solutions (Endres & Chowdhury, 2013; Hong, Ye, Du, Wang, & Fan, 2020; H. Yang, Yan, Jia, & Liang, 2021). When virtual communities encourage users to voice diverse opinions, they serve to prevent groupthink (Phan et al., 2019). Groupthink is detrimental to innovation and typically encourages the adoption of ineffective solutions to problems (Endres & Chowdhury, 2013; Kakar & Kakar, 2018). Moreover, allowing diverse opinions in the community can increase participation and member commitment to the virtual community (Kang, Lee, Lee, & Choi, 2007). A lack of group diversity and the absence of diverse opinions impairs the accuracy of information generated by virtual community participants (Xie, Chen, & Hu, 2020).

4.2.1 Virtual communities in times of disaster

Disasters are generally marked by *'high levels of information need and low levels of information availability'* (Shklovski, Burke, Kiesler, & Kraut, 2010). People need verifiable, accurate and reliable information (i.e., VAR information) about disasters in a timely manner (Jurgens & Helsloot, 2018). In response to disasters' sudden onset, people often gather on social media or other web platforms to learn about the situation or take protective measures (Lingyao Li, Bensi, Cui, Baecher, & Huang, 2021; Nan & Lu, 2014; Qu et al., 2009; Tim et al., 2017). People on these platforms also provide social support (either tangible aid or

emotional support) to disaster victims and praise each other's efforts (Lingyao Li et al., 2021; Nan & Lu, 2014).

People use virtual communities during both natural (e.g., hurricane, earthquake, disease outbreak) and man-made (e.g., riot, terrorist attack) disasters. During Hurricane Cindy in 2017 (J. Kim, Bae, & Hastak, 2018), the Sichuan earthquake in 2008 (Nan & Lu, 2014), the Chennai floods in 2015 (Bhuvana & Arul Aram, 2019), the Virginia tech shooting tragedy in 2007 (Vieweg et al., 2008), the Manchester bombing in 2017 (Mirbabaie & Marx, 2020) and the Mumbai terrorist attack in 2008 (Oh et al., 2013) people created or appropriated virtual communities for real-time communication and to exchange disaster-related information. More recently, during the COVID-19 outbreak, people have used virtual communities to stay socially connected, to share information on symptoms, vaccines, and travel routes (Vogel, Kurtz, Grotherr, & Böhmann, 2021).

However, a common problem in virtual communities is the trustworthiness and relevance of information generated by community participants (Mirbabaie, Bunker, Stieglitz, Marx, & Ehnis, 2020; Silver & Matthews, 2017). Widespread falsehoods (e.g., fake news, misinformation, and disinformation) and the sheer volume of information on virtual communities can put disaster victims at risk (Luna & Pennock, 2018; Oh et al., 2013; Rai, 2020). Such falsehoods and irrelevant information can be spread unintentionally or deliberately (Silver & Matthews, 2017). For example, wrong shelter locations were disseminated deliberately during the 2011 Japan earthquake and tsunami. Journalists shared unverified information during Hurricane Maria in 2017 (Kwanda & Lin, 2020). The spread of many falsehoods about the novel coronavirus during the COVID-19 outbreak has led to the preventable loss of lives and constitutes a threat to public health (Dwivedi et al. 2020).

Additionally, the sheer volume of information available in virtual communities in times of a disaster can cause uncertainty and anxiety (Mirbabaie, Stieglitz, & Brünker, 2021).

Disseminated information often overlaps and is contradictory (Rao, Plotnick, & Hiltz, 2017). Disaster victims often struggle to differentiate between reliable and unreliable information. Unreliable information can delay disaster response and effective decision-making. Disaster victims might not be able to easily find VAR information when they need it (Scheufele et al., 2021; Simon, Goldberg, & Adini, 2015).

Counteracting these problems (e.g., fake news, the sheer volume of information) associated with VAR information dissemination requires collective problem-solving effort by virtual community members. Previous IS research has suggested that group diversity and making diverse information available to virtual communities makes the community more effective in solving problems (Chu, 2009; Divakaran & Nørskov, 2016; Kudaravalli & Faraj, 2008). Diversity among community members is seen as a key condition for the emergence of collective intelligence during disasters. For example, during the 2010 Haiti earthquake, more than 1000 digital volunteers from approximately 50 countries provided an online translation and information processing service for disaster victims (Park & Johnston, 2017). Conversely, the lack of diversity creates a breeding ground for falsehoods (Campan, Cuzzocrea, & Truta, 2017). The above discussion of group diversity and virtual community leads us to summarize the conclusions of previous research in Figure 4.1.

Figure 4. 1 Conclusions of previous IS research

However, in our study we discovered just the opposite. While diversity might be good under normal circumstances, during a disaster diversity can hinder the provision of VAR information. This led us to pose the research question we mentioned earlier viz. How and why does diversity in a virtual community hinder the dissemination of verifiable, accurate and

reliable information during a disaster? As we analysed our data, the idea of organizational mindfulness/mindlessness and collective identity emerged that helped us to figure out the answer. Below we discuss these theoretical constructs (and their sub-constructs) in more depth.

4.2.2 Theoretical foundations: Organizational mindfulness

Organizational mindfulness is the extent to which an organization can assess emerging threats and capture discriminatory detail so it can respond in a timely manner (Vogus & Sutcliffe, 2012; Weick & Sutcliffe, 2015). Organizational mindfulness reflects a state where an organization is fully alert and conscious of the present situation (Levinthal & Rerup, 2006; Nwankpa & Roumani, 2014). A mindful organization has various ways to solve problems and reduce the threats it encounters. Research has found that leveraging organizational mindfulness can ensure high quality IT innovation (Fichman, 2004; Swanson & Ramiller, 2004) and better operational performance (Madsen, Desai, Roberts, & Wong, 2006). As there have been calls for further research regarding the link between crisis management and mindfulness Williams et al. (2017), our paper provides one answer to this call by focusing on the disaster information management process in virtual communities.

Organizational mindfulness can be conceptualized as a five-dimensional construct comprising:

(1) Preoccupation with failure involves the organization's willingness to encourage the open discussion of problems, reporting errors, and developing effective ideas or ways of looking at things (Ray, Baker, & Plowman, 2011; Karl E Weick & Sutcliffe, 2015). Preoccupation with failure also refers to deliberate and active attention to notice and deal with potential threats (Vendelø & Rerup, 2020; Vogus & Sutcliffe, 2012). A mindful organization believes that the current system is flawed and unexpected events are preventable (K E Weick, Sutcliffe, & Obstfeld, 1999). It treats any failure (e.g., all failures and near- failures) as indicators of potentially larger problems (Butler & Gray, 2006).

(2) Reluctance to simplify interpretations means an organization resists jumping to simple conclusions (Weick & Sutcliffe, 2015). It refers to an organization-wide awareness that the uniqueness of a problem should be considered before employing a solution (Hales & Chakravorty, 2016). A mindful organization that demonstrates a reluctance to simplify interpretations questions how things are usually done, challenges the status quo, and appreciates scepticism (McAvoy, Nagle, & Sammon, 2013). A mindful organization stays focused on the present moment and discourages a 'one size fits all' approach (i.e., maintaining routines) to all problems. Instead, it identifies the root causes of a problem by seeking diverse perspectives from different people (Hoy, 2003).

(3) Sensitivity to operations refers to an organization's vigilant attention to the circumstances it faces and efforts to build situational awareness of an operation (Jahn, 2019; Klockner, 2017; Weick & Sutcliffe, 2015). A mindful organization does not passively receive information. Instead, it proactively strives to understand what is happening (Klockner, 2017). When an organization demonstrates sensitivity to operations, it can adapt current behaviour to take advantage of changing circumstances.

(4) A commitment to resilience refers to developing organizational capabilities to adapt and learn to respond and recover from errors and unexpected events (Klockner, 2017; Vendelø & Rerup, 2020). These capabilities form when the organization is able to improvise solutions (i.e., create new or adjust existing solutions) to deal with them (Jahn, 2019; Weick & Sutcliffe, 2015).

(5) Deference to expertise refers to an organization's commitment to empower those who possess relevant expertise about an issue or problem to have authority over it, regardless of hierarchical position (Jahn, 2019; Ray et al., 2011; Weick & Sutcliffe, 2015). A mindful organization typically discourages excessive formal rank in an emergency because the ranking

individual may not be available when the event occurs or have requisite knowledge and skills (Hales & Chakravorty, 2016).

Organizational mindlessness

In contrast to organizational mindfulness, organizational mindlessness refers to a state of reduced attention and alertness (Dernbecher & Beck, 2017; Fiol & O'Connor, 2003). Organizational mindlessness occurs when an organization demonstrates ignorance of failure and tries oversimplifying and normalizing events which can lead to unreliable outcomes (Dernbecher & Beck, 2017; Weick et al., 1999). Organizational mindlessness restricts the ability of an organization to react in a flexible manner (Weick et al., 1999). The behaviour of a mindless organization is rigid and rule-governed, regardless of the current circumstances (Dernbecher & Beck, 2017; Eastburn & Boland, 2015). A mindless organization becomes trapped in past categories, acts as if it is on automatic pilot and fixates on a single perspective (Fiol & O'Connor, 2003; Rerup, 2005; Weick et al., 1999). Below we discuss three dimensions of organizational mindlessness:

(1) Entrapped in past categories: A mindless organization uses the same routines regardless of their appropriateness to the present conditions (Levinthal & Rerup, 2006). It tends to look for shortcuts by overusing existing categories and becomes unwilling to change existing ways of doing things (Rerup, 2005). It often uses familiar or historical solutions that were successful in the past to solve current problems without taking their current effectiveness into account.

(2) Automatic action: A mindless organization acts without conscious thought because of assumed familiarity with the task being performed. Automatic actions differ from being entrapped in past categories in that these are unconscious/automatic behaviours and not taken from tradition (Fiol & O'Connor, 2003). A mindless organization automatically performs the same actions in the same way without considering the present situation. It strictly follows every

step of a bureaucratic process, although it may not be meaningful for the present situation. Thus, being in a mindless state, its awareness of the present moment is always clouded, which eventually results in adopting ineffective solutions for the current situation (Dernbecher & Beck, 2017).

(3) Fixated on a single perspective: A mindless organization is often reluctant to consider other possible perspectives (Eastburn & Boland, 2015; Fiol & O'Connor, 2003; Rerup, 2005; K E Weick et al., 1999). It tends to ignore negative feedback. Fixation on a single perspective occurs when an organization enacts an action knowing that the action will worsen the situation.

During disasters, research suggests that participants of a virtual community need to collectively and mindfully address the disaster (Klockner, 2017). Our data suggests one way to achieve collective mindfulness is through collective identity.

Collective Identity

Collective identity is a shared sense of belonging to a group (Priante, Ehrenhard, van den Broek, & Need, 2018; Stewart & Schultze, 2017). It can be conceptualized as a consensus definition of group membership, boundaries, and activities (Johnston, Larana, & Gusfield, 1994; Taylor & Whittier, 1992). For example, a group can define itself as activist bloggers (Soon & Kluver, 2014), lesbian feminists (Taylor & Whittier, 1992), Indians or South Asians or Asians (Bacon, 1999). The construction of collective identity is particularly crucial in social groups that are informally formed around common interests and whose membership is voluntary (Fayard & DeSanctis, 2010; Stewart & Schultze, 2017). Virtual communities are examples of such social groups where collective identity has been found to positively influence engagement, strengthen trust, and forge emotional bonds (Carter & Grover, 2015; Ren et al., 2012).

Four dimensions characterize collective identity: (1) boundary demarcation, (2) shared consciousness, (3) solidarity and (4) emotional investment.

(1) Boundary demarcation means one distinguishes whether others are a member of the collective (Chua, 2009; Taylor & Whittier, 1992). Those who share the collective identity are the in-group, and those who do not are the out-group (Chua, 2009). This in-group/out-group distinction is expressed through identity signifiers such as distinct social and cultural practices (e.g., using common symbols, shared languages, and rituals) (Soon & Kluver, 2014). These practices act as boundary markers and create an "us" (in-group) and "them" (out-group) dichotomy, which enables members of an in-group to distinguish themselves from the out-groups (Hunt & Benford, 2004; Soon & Kluver, 2014).

(2) Shared consciousness arises from members' recognition of commonalities such as shared goals, similar values, religious or ethnic background, and nationality (Soon & Kluver, 2014; Taylor & Whittier, 1992). Shared consciousness causes members to feel a moral obligation to conform to group norms and help those within the collective (Panas & Ninni, 2011).

(3) Solidarity refers to the ability of in-group members to recognize, and be recognized, as belonging to the same social unit (Melucci, 1996). When in-group members feel a sense of solidarity they cooperate and act together in pursuit of common goals. Solidarity promotes a feeling of mutual trust based on their shared problems within the collective.

(4) Emotional investment is an emotional attachment to the community or common feelings by members of a group as a result of shared experiences (Ashmore, Deaux, & McLaughlin-Volpe, 2004; Hopkins et al., 2016; Lawlor & Kirakowski, 2014; Voronov & Yorks, 2015). A certain degree of emotional investment by members is required to foster collective identity (Coretti & Pica, 2015; Melucci, 1996; Polletta & Jasper, 2001). This helps group members form sympathetically intimate relationships, leading to stronger bonds within the collective (Melucci, 1996; Paxton & Moody, 2003). Research suggests that positive

emotional feelings can keep members involved in the face of uncertainty, while a hostile feeling can deter participation (Gravante & Poma, 2016).

Although boundary demarcation, shared consciousness, solidarity and emotional investment, are conceptually distinct, they are not orthogonal; They can overlap and occur simultaneously. For example, in the 1970s, a group of radical lesbian feminists used the slogan "the woman identified woman" to indicate the in-group (i.e., radical lesbian feminists). They also used this slogan in their campaign to protest the exclusion of lesbians and lesbian issues from the feminist movement (Samek, 2015). Hence, this slogan simultaneously addressed all four dimensions - boundary demarcation, shared consciousness, solidarity, and emotional investment.

4.3 Methodology

We conducted an in-depth, qualitative cross-case analysis (Miles & Huberman, 1994) of a virtual community, the r/Houston subreddit, looking at what caused this community to fail or succeed to provide VAR information in two disaster scenarios. The first (i.e., Hurricane Harvey in 2017) is an example of successful provision of VAR information. The second (i.e., the Great Texas Freeze Out in 2021) is an example of failure.

Hurricane Harvey in 2017 and the 2021 Great Texas Freeze Out disasters were selected as critical incidents in this community based on the following selection criteria. First, we began our research with the 2017 Hurricane Harvey case and found the r/Houston community was successful in provisioning VAR information. However, we also noticed the success was not deliberate. Instead, the community underwent a transition from failure to success. The findings from the Hurricane Harvey case have been and are being published elsewhere (redacted). Second, the 2021 Great Texas Freeze Out was chosen serendipitously. The first author embedded himself in the research site for over a year, studying the hurricane, and keeping up to date with community activities. In recent times, the r/Houston community has experienced

several other disasters (e.g., the Great Texas Freeze Out and COVID-19). To our surprise, the lessons learned from the hurricane appear to have been unlearned leaving the community ill equipped to handle these subsequent disasters. We ruled out COVID-19 as a comparison, because the disaster is taking a long time and the duration of the disaster might be a confounding factor in explaining community failure. In contrast, the Great Texas Freeze Out has strong similarities to the hurricane- it was a predicted, acute natural disaster, and lasted for a relatively short time, yet the community did not respond to it in the same way. These similarities thus allowed us to explore and better understand the key obstacles in virtual community-led effective disaster response within the same virtual community.

4.3.1 Research Site

We chose the r/Houston subreddit (i.e., a virtual community) as our research site for four reasons. First, this community communicates in English. Second, it allows group diversity (i.e., anyone can participate regardless of their geographic boundary and ethnic or racial status) and diversity of opinions. It is thus possible to observe how and why diversity may hinder the successful provision of VAR information in times of disasters. Third, this community has encountered several disasters, thereby allowing us to compare the differences and similarities in VAR information provision over time. Fourth, Reddit data is archived and open to the public, making data collection straightforward.

4.3.2 Data sources

Community-generated archival data in Reddit was our main data source. Reddit is a social news aggregation and discussion platform of self-governed virtual communities. Reddit ranks in the top 10 most-visited sites in the USA and top 20 globally. Unlike other discussion platforms (e.g., Twitter), Reddit naturally divides into subreddits (i.e., self-created communities of users, united by a certain topic). Registered Reddit users can create threads that contain a title and a description box where they can either attach an external link or a self-

written piece of content. They can choose to create threads in a specific subreddit which becomes available to other registered users for voting and commenting. Users can express their positive and negative opinions about the threads and comments by using an upvote or downvote, respectively. The comments in a thread are structured as a discussion tree where users can either reply to the thread itself or add other comments. Figure 4.2 illustrates the schematic structure of a subreddit.

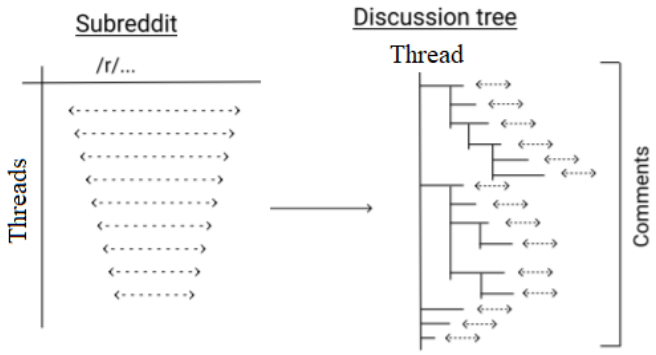

Figure 4. 2 Schematic structure of a subreddit

4.3.3 Data Collection

Digital trace data were collected from the r/Houston subreddit. For this paper, our dataset comprises data from two different disaster scenarios: the first (i.e., Hurricane Harvey) occurred between August 25, 2017 and August 31, 2017; the second (i.e., the Great Texas Freeze Out) between February 12, 2021 and February 19, 2021. We first collected all threads (and associated comments) that were created during the time of the disasters from the selected research site. We initially used the Reddit search tool to extract these threads and comments. However, the Reddit search tool limits retrieval to 1000 threads per query. Therefore, we also used the publicly available data from Reddit archived on Google Big Query and PushShift (i.e., a social media data collection and archiving platform). Table 4.1 presents a summary of r/Houston subreddit data that we collected.

Research Site (r/Houston Subreddit)	**Hurricane Harvey** (Aug 25- Aug 31, 2017)	**Great Texas Freeze Out** (Feb 12- Feb 19, 2021)
Total number of threads created	5315	1143
Total number of comments made	99078	42345

Table 4. 1 Summary of the r/Houston subreddit data

4.3.4 Data Analysis

Data were collected and analysed iteratively. To analyse the data, we first performed a within-case analysis for each case and then searched for emergent cross-case patterns (Eisenhardt, 1989). Our analysis was guided by the logic of constant comparative analysis (Charmaz, 2000) to find initial concepts, link these concepts to higher-level categories, and then identify relationships between the categories as appropriate (Sarker, Sarker, Sahaym, & Bjørn-Andersen, 2012). As a result of this process, three themes emerged: organizational mindfulness, organizational mindlessness and collective identity. We then re-coded our data based on the definitions of organizational mindfulness/mindlessness and collective identity.

In the Harvey case, we noticed a transition from an initial lack of leadership to one where clear leaders emerged to overcome the issues associated with VAR information dissemination. Particularly, we found the r/Houston community acted mindlessly at the onset of the disaster, but after a new temporary moderator was appointed, they acted collectively and mindfully to keep VAR information flowing. However, the community remained mindless throughout the Freeze Out case. Therefore, we present our findings on Hurricane Harvey in two episodes, the mindless and mindful episodes, but present the Great Texas Freeze Out as a single episode, as there was no clear shift to mindfulness.

We confirmed our observation of organizational mindful/mindlessness based on definitions from the literature. Evidence was coded as mindful if it satisfied at least one of the five dimensions: *preoccupation with failure, reluctance to simplify interpretations, sensitivity to operations, commitment to resilience, or deference to expertise*. Although one piece of evidence could map to multiple dimensions, we focused on identifying evidence than mapped

to one dimension rather than finding dimensional overlap. In our coding, we also observed that during the Hurricane Harvey mindful episode, the r/Houston community adapted its Reddit usage practices (i.e., the appropriation of different features of the Reddit platform) to disseminate VAR information. For example, the moderators used "highlighting" features to make important information prominent. Hence, we also explored how different Reddit features were applied during the Hurricane Harvey mindful episode.

We coded an action as *preoccupation with failure* if the moderator/community user noticed limitations in their current way of disseminating VAR information and suggested (developed) effective solutions. An action was coded as *reluctance to simplify interpretations* if the moderator/community user consciously questioned the automatic routines (i.e., the applicability of their standard operating procedures) and adopted new Reddit usage behaviour in line with the present situation. An action was *sensitivity to operations* if the moderator acknowledged and corrected problems raised by the community users and used Reddit features in an innovative way. An action was coded as *commitment to resilience* if the moderator/community user adapted solutions (i.e., created new or adjusted existing solutions by incorporating Reddit features) to the present situation to facilitate VAR information. Lastly, we coded an action as *deference to expertise* if the moderator recognized users with relevant expertise and allowed them to make decisions.

Organizational mindlessness was similarly identified if the action satisfied at least one of its three dimensions: *entrapped in past categories, automatic action, or fixate on a single perspective*. Although an action could map to multiple dimensions, we focused on identifying evidence than mapped to one dimension rather than finding dimensional overlap. We coded evidence as *entrapped in past categories* if the moderator/community user continued using familiar or historical solutions to solve current problems regardless of the effectiveness of historical solutions. We coded evidence as *automatic action* if the moderator/community user

suggested (developed) a solution only following community regulations or past experiences without considering if it was appropriate under the present situation. Evidence was coded as *fixated on a single perspective* if after the solution was used and proven ineffective, the community users informed the moderator that the solution was not working, but the moderator continued to use the same solution.

Additionally, when we studied the Hurricane Harvey data, we observed the presence of homogeneity (i.e., a dominant in-group within the community). For example, individuals from Houston identified themselves as *'Houstonian.'* Conversely, in the Freeze Out case, no dominant in-group was observed. Instead, several subgroups emerged. Below we discuss each of the collective identity dimensions in relation to our data analysis.

Boundary demarcation. Boundaries were assessed based on the different types of identification and identity signifiers (e.g., political affiliation, place of residence) members used to define the boundary. We also looked at how references were made to different collectives. For example, those who made we-references (e.g., 'we', 'our') were related to in-group and those who made you-references (e.g., 'you', 'your') were related to out-groups.

Shared consciousness. Data were analyzed to ascertain what the group members considered as their shared goal(s) during the disasters studied. We also attempted to identify what the members did to achieve their shared goals.

Solidarity. Solidarity was assessed based on the in-group members' recognition of each other and their willingness to support and act together to solve problems arising from the disasters studied.

Emotional investment. Finally, we attempted to identity how emotions (i.e., positive and negative feelings) were expressed through language use. Particularly we looked at how the in-group members reacted to out-groups and vice versa.

After coding, we separated the data into three parts- pre-mindful Harvey, post mindful Harvey, Freeze Out. We observed collective identity only in post-mindful Harvey and further interrogated our data to determine why. Table 4.2 shows identities and their goals observed in both disasters. We realized that the separately identified collective identities had separate goals. For example, during Harvey, Houstonians wanted to survive. People outside Houston spreading rumors had a non-survival agenda. This led us to the insight of goal consensus. By goal consensus, we mean virtual community users have a shared understanding of the goals or purpose of the community during the disaster (Provan & Kenis, 2007; Tyler & Kapucu, 2021). We further interrogated it to determine why collective identity formed in Harvey but not during the Freeze Out. It was from this interrogation we realized that when virtual communities act mindlessly and fail to develop goal consensus around helping with the disaster, they cannot provide VAR information.

As a result of this analysis, we identified a common theme: *the lack of goal consensus* can inhibit the flow of VAR information during a disaster. We elaborate on this finding below.

Hurricane Harvey		
Identity	**Goal**	**Remarks**
Houstonian	Collectively cope with Disaster through sharing local information, providing material assistance and feeling emotionally connected	This collective identity represents individuals who lived in Houston or had an attachment to Houston
Non-Houstonian Samaritan	Offering help, sharing expertise knowledge, showing sympathy	This collective identity represents individuals who were not from Houston but helping Houstonians
Non-Houstonian Non-Samaritan	Propagating falsehoods, political blaming, posting irrelevant information, scamming, posting insensitive comments	This collective identity represents individuals who did not live in Houston and not helping
The Great Texas Freeze Out		
Identity	**Goal**	**Remarks**
Samaritan	Offering help, providing useful information, showing sympathy	This collective identity crosses Houstonians and Non-Houstonians
Wrong Samaritan	Providing harmful advice	This collective identity applies to Non-Houstonians

Authority denier	Rejecting information from authority	This collective identity crosses Houstonians and Non-Houstonians
Authority supporter	Supporting information from authority	This collective identity applies to Houstonians
Mocker	Posting insensitive comments	
Falsehood spreader	Spreading falsehoods about the freezeout	
Republican	Supporting the media narrative of false wind power failure, Political blaming	
Democrat	Rejecting the media narrative of false wind power failure, Political blaming	This collective identity crosses Houstonians and Non-Houstonians

Table 4. 2 Identities and their goals

4.4 Findings

Our findings address how and why diversity might inhibit the flow of verifiable, accurate, and reliable (VAR) information in virtual communities during a disaster. For each case, we present (1) what identities emerged in the field site that helped (or did not help) disseminate VAR information, and (2) how the ways of managing the community members and generating information (governance) affected the mindfulness or mindlessness of the virtual community during a disaster.

Case I: Hurricane Harvey

Hurricane Harvey made landfall near Corpus Christi, Texas on August 25, 2017. The Category 4 hurricane threatened millions of residents with 130-mph winds, heavy rains, and left people without power. Later, Harvey moved slowly inland towards Houston where it remained for four days and caused extreme flooding. Residents staying in the area ran low on food, safe drinking water and gas. The official emergency number, 911, was overloaded and victims turned to virtual communities to request help (Luna & Pennock, 2018). The National Hurricane Center ceased tracking Harvey's remnants on August 31.

During the Hurricane, people from Houston and outside of Houston visited the r/Houston community. They made multiple requests for information by creating individual threads or commenting on existing threads in the r/Houston subreddit. Many others posted offers of service, and messages of assurance such as ‘stay safe.’

Identity

The r/Houston community during this disaster exhibited explicit collective identity formed around geographic boundaries as well as around common goals such as helping disaster victims. These included:

Houstonian: Individuals who lived in Houston identified as Houstonian. These Houstonians turned to the r/Houston community to seek local information pertinent to their respective area. Information exchanged included knowing the current hurricane situation, general advice, shelter location, road conditions and where to find drinking water. For example, they wanted to check which roads were not flooded in Houston so they could evacuate and went to the nearest shelter.

“Houstonian here. Just got this evacuation order. Does anyone have a map of what areas are flooded and what streets? I want to find an evacuation route but can't find a clear one. Please help.”

Many Houstonians sought information on volunteer opportunities such as where to donate food and clothes.

My fellow Houstonians of Reddit, I would like to know where to volunteer. Let's come together… does anyone know of any accessible places where I can help out?

Although most r/Houston users lived in Houston, a sizable minority who identified as Houstonian were not living in Houston. For example, many participants were born in Houston and later moved to another city. They were worried about their families and fellow Houstonians.

I'm a native Houstonian living in SF anxiously watching these evacuation maps inch closely to my parents.

During the hurricane, r/Houston Houstonians felt emotionally connected to each other. They sent their thoughts and prayers to disaster victims.

> *Thoughts and prayers for those affected by the tornados this morning. Everyone stay safe today. Waiting for daylight here in the Bear Creek area to see if there is any local damage but it seems that we are all safe for now.*

Moreover, a large number of Houstonians who went through similar experiences earlier expressed their solidarity with disaster victims. For example, a Houstonian was very anxious and could not sleep because he was afraid of rising water levels. Other Houstonians posted message of assurance to comfort the victims.

> *Don't worry, you'll most likely have 10's of thousands of friends with you in the same place. I'm right there with you. It's going to suck, but it will be okay. We can do this.*

Non-Houstonian Samaritan: During the Hurricane, individuals who were not from Houston but provided assistance that was well-intentioned we identified in our data as Samaritan. They offered help (e.g., donating money, food, clothes) and shared expertise that was useful to Houstonians. For example, a meteorologist from Virginia shared real-time weather updates and shared disaster models with the r/Houston community.

> *Heads Up- Radar is showing a band E of Houston, S of Houston and W of Houston possibly converging, bring very heavy rains again to Houston proper and all points N, S, E and W.*

These Samaritans also expressed their concerns for disaster victims and provided emotional support.

> *Checking in from r/NewOrleans. Really sad to see what you all are dealing with. Please stay safe and let us know what you all need. We're family.*

Non-Houstonian Non-Samaritan: Anyone who was not from Houston and posted ill-intentioned information we identified as non-Houstonian non-Samaritan. During the disaster, these non-Samaritans criticised Houstonians for not evacuating early and Houston officials for not issuing early evacuation order.

> *Am I wrong for thinking Mayor Sylvester Turner is a terrible person for ignoring Corpus' mayor telling Houston to evacuate? I'm not from the area... but why did you not evacuate?*

Houston is the most populous city in Texas, and fourth-most populous city in the United States. It (Greater Houston) has a population of 6.5 million. Evacuating a large of number people simultaneously was beyond the capacity of the Houston highway system. Houstonians answered the criticisms made by non-Houstonian non-Samaritans.

> *I know my fellow Houstonians understand this but I don't think anyone outside of here fully understands why evacuation was NOT an option for Mayor Turner. Asking everyone to evacuate before the storm hit would have caused a major traffic jam like Rita and Katrina.*

Some non-Houstonian non-Samaritans started political debates, for example by criticizing the Mayor for not issuing an early evacuation notice because he was a Democrat (one of the two major American political parties). However, Houstonians contradicted this claim and urged everyone to stop dragging politics into the community discussion.

> *We're not democrats or republicans right now. We're goddamn Houstonians. And above that we are Texans. We'll all get through this together. Please don't update the Houston thread with the fight at this time.*

Moreover, many non-Samaritans deliberately propagated fake news and misinformation. They made claims without providing supporting evidence or mentioning official information source. Some of these claims were fabricated or unable to be verified. For example, someone shared that an alligator was seen in the Meyerland area. Another person posted saying that they heard from their friends that the city of Houston shut down the water across Houston and other areas. Others mindlessly shared fake news without authenticating the information source.

A group of non-Samaritans also promised fake financial aid, rescue support, and posted phony webpages (e.g., google forms) to steal credit card and personal information. For example, a person was seeking rescue support for his in-laws but scammers replied with links to bogus help forms that looked like they were from trusted sources.

> *Who is this scammer. This is the second post I've seen this copypasta on.*

Governance

Pre-mindful episode

Virtual communities typically allow users to create individual threads or comment on the existing threads if they want to seek or provide information. Initially, the r/Houston virtual community was not any different. At the onset of the hurricane, r/Houston users followed the same routines to seek information (entrapped in past categories). However, the multitude of generated threads made it difficult to obtain specific useful information as such information was scattered across multiple threads. For example, a disaster victim was unable to find a disaster map that someone shared earlier.

> *I know they had a map showing where the water will be heading. Unfortunately can't find it on here.*

Furthermore, a large number of threads asked for the same information and many responded to these threads with conflicting or erroneous information. In non-disaster situations, virtual community users visit the community to seek or share information. Moreover, most users do not verify whether the information is accurate or fake before sharing it with others, regardless of age, social class or gender, because of the urgency of the disaster situation (Khan & Idris, 2019). It was difficult to know which threads contained VAR information that disaster victims could use. While the r/Houston community wanted a better way to find useful information, there were no structural mechanisms in place that could help people easily segregate useful and not so useful information (entrapped in past categories). The following quote illustrates this problem:

> *I was looking for a list of emergency shelters. I found multiple posts [threads] mentioning different locations that are not even in Houston. Where can I find verified information?*

Providing useful and timely information is critical in a disaster. However, when people visited the r/Houston community they could not see new information (thread or comment) first. This is because, the default configuration on Reddit (which r/Houston used) sorts threads based

on popularity and sorts comments in a thread based on the ratio of upvotes to downvotes (entrapped in past categories).

People vote for visibility in situations as this that way important information goes to the top.

The r/Houston users also sought and failed to find list information (e.g., list of emergency numbers, list of shelters, list of places seeking volunteers). They urged the moderators to compile such information in a single thread and pin it.

Mods, can we get a volunteer opportunities thread stickied? We really need a sticky or megathread for volunteer opportunities.

However, the moderators ignored the feedback and demonstrated mindlessness by arguing the constraints of the Reddit platform prevented them from organizing the information in a better way (fixate on a single perspective).

Reddit only allows for two stickied [pinned] posts. Complain to the [Reddit] admins, not the moderators.

The difficulty in identifying useful and timely information contributed to frustration in the r/Houston community. However, the moderators mindlessly followed existing routines (i.e., allowed people to create individual threads, used default configuration to sort threads and comments) to disseminate disaster information (entrapped in past categories/fixate on a single perspective). While disaster victims continued expressing their frustration, one mindful Houstonian suggested a solution: he requested the r/Houston moderators to create a special single thread (called a megathread). The vision was that the megathread would be on top of the pile of threads, so all information would be collated in a central place. Several others voiced their support for the suggested solution (preoccupation with failure).

Fun times ahead. Hopefully the mod [moderator] team can create a megathread for the tropical storm? /u/ [moderator's name withheld]?

Post-mindful episode

Following the suggestions from the community members, the r/Houston moderators mindlessly created a megathread. The initial megathread was not very successful. Its title

("Yeah, this weekend is looking wet for Texas") failed to clearly articulate that it was a megathread. The original requestor highlighted the problems (preoccupation with failure). As both moderators were outside Houston during the hurricane, they appointed this person as a guest moderator and he started creating new megathreads (deference to expertise).

It was always the understanding that I was going to be a guest mod [moderator]…that way, I could sticky the megathreads and delete trolling comments in those megathreads.

Every megathread on Reddit follows particular characteristics. First, only moderators can create a megathread. Second, a megathread requires a title, a description box (to describe what the megathread is about) and an initial comment (optional).

Megathreads were created for each day of the hurricane and were titled Hurricane Harvey Megathread (Day X). The common name of the megathreads made them easy to search for. The description box of every megathread contained links to the official sources. The initial comment contained the current public service announcements issued by authorities as well as other useful information such emergency numbers, a list of open shelters, volunteer opportunities and evacuation routes (commitment to resilience). The guest moderator also used Reddit's *'sticky'* feature (i.e., when moderators sticky a thread or comment it appears at the top of a pile of threads or comments regardless of its popularity or time since posting) to pin the megathread for that specific day, so users knew where to look for critical information (sensitivity to operations).

I [guest moderator] edited and linked to a bunch of stuff in my comment so this megathread will be more useful. :)

The moderation team returned to Houston on day 3 and took over creation of the megathreads. They followed the new megathread practice until the hurricane was over. Furthermore, moderators changed the default configuration of comment sorting to "new" so people could see recent information first (commitment to resilience).

Not, true. In this thread [megathread], sorting is done so that people see newer stuff first. Downvotes, upvotes don't matter much in this instance.

The moderators also demonstrated mindfulness by using available features in Reddit in an innovative way (sensitivity to operations/ reluctance to simplify interpretations). One such feature is *'highlighting'* information by changing the background color of text in a post. Moderators highlighted comments in the megathreads in green that they perceived as containing useful information. As a result, people could quickly distinguish useful and not so useful information while reading voluminous comments in the megathread.

> *We have 2 spots to sticky things, that's it and there's a lot of stuff that would be great as stickies. That's why we're highlighting important lists green.*

The creation of megathreads did not solve all the problems and new problems emerged. There was an overabundance of information in the r/Houston community, some accurate and some not. People required VAR information from their fellow disaster victims to know what happened in affected areas. However, since r/Houston supports open participation and anonymity (i.e., users can join from anywhere and they can use pseudonym to maintain their privacy), people could easily share inaccurate information without fear of repercussion.

As mentioned previously, during hurricane Harvey, many non-Houstonian non-Samaritans deliberately propagated falsehoods in the r/Houston community. A significant number of Houstonians noticed the spread of falsehoods in the r/Houston community and felt a moral obligation to act in favour of a safer community (i.e., community that provides VAR information). They were also aware of the negative impacts these falsehoods could have on disaster victims. For example, they spotted a non-Houstonian non-Samaritan who posted false evacuation information and blamed the Houston officials for not issuing evacuation notices. They reported this issue to moderators and requested them to remove unwanted users (preoccupation with failure).

> *If you're not from Houston really not cool of you judging our posters [individuals from Houston] at our most vulnerable time...Mods, can you remove this moron?*

On Reddit, it is possible to put a mark beside a user's identity (called a user flair) that carries information about the person. A consensus emerged among Houstonians that moderators should introduce new "user flairs" to identify people who lived in Houston (i.e., location of information seeker and provider) (reluctance to simplify interpretations).

Mods [moderators], can you create new flairs? We need to know who these people are!

The r/Houston moderators listened to the Houstonians' request and created new flairs to indicate the location of individuals seeking or providing information (sensitivity to operations). Moderators also created flairs to indicate if people had particular valuable areas of expertise (e.g., meteorologist). These flairs helped to establish and maintain in-group/out-group boundaries within r/Houston. It was possible to distinguish between Houstonians, non-Houstonian Samaritans and non-Houstonian non-Samaritans. Individuals who were identified as Houstonian and non-Houstonian Samaritans were the in-group and all others were out-group. For example, the meteorologist was a non-Houstonian Samaritan but his goal was to help disaster victims by sharing expertise knowledge.

Below is an example of a flair that moderators created to indicate a neighbourhood in Houston. People recognized the value of flairs as they could identify who belonged to Houston. For example, a person from the energy corridor was explaining the rescue situation in highway 6 without mentioning the exact area name. However, others identified the area via his flair.

Posted by r/username/ Boulevard Oaks ← *flair*

Judging by their flair, they're talking about the area by 6 and I-10.

To combat the spread of falsehoods, Houstonians suggested that any claim must be backed by evidence (e.g., a picture or a video) or by a link to official sources. For example, a person claimed there was water in certain areas although these places were dry. Houstonians started utilising Reddit's voting feature (i.e., upvote/downvote) to indicate reliable information.

Evidence-based claims received many “upvotes,” and those deemed unworthy or false were “downvoted” (commitment to resilience).

If that's true take a picture and report it. If it's not true stop spreading fake news.

Houstonians also actively patrolled the site and reported fake news to the moderators (commitment to resilience).

Please report comments you think warrant removing. Mods [moderators] can't be everywhere at once, especially right now.

Moderators took the information Houstonians gave and banned troublesome members from r/Houston. They also removed fake and irrelevant content. Moreover, the moderators actively policed non-megathreads and advised people to redirect their questions to the appropriate megathread (commitment to resilience/sensitivity to operations).

Hey /r/houston, we've been cleaning out a lot of stuff from the subreddit to try to keep more important info at the front page… General questions are still best posted in the megathread discussion! It's super active and sorted by new so your stuff gets seen.

r/Houston users started appreciating moderators for the new ways of organizing information. They found the megathreads were useful throughout the hurricane. Falsehoods and conflicting information were quickly deleted. They were able to find real-time VAR information and connect with each other.

While I had the news on, accurate and up to date information was posted on here [megathreads] with replies before I saw it elsewhere. False information and crap posts were quickly tossed out.

Case II: Great Texas Freeze Out

From February 10-20, 2021, Texas was hit by three storms. Temperatures in Texas dropped to -2F/-19C- the coldest on record in 72 years. As a result of the record low temperatures, the Texas electricity grid failed. Many Texan power generators, especially those located in the southern and eastern areas, were not designed to withstand freezing temperatures, given those areas of Texas normally have milder climates. The record freezing temperatures simultaneously increased demand for energy and caused more than 30 power plants to fail. The

Texas power grid was deliberately designed to be isolated from the rest of the American electricity grid to avoid Federal Government oversight. This meant additional power could not be brought in from neighbouring states.

Water pipes across Texas also froze and burst. As a result, 4.5 million Texan homes, which were not designed to insulate against the cold, were without both power and running water. In total, the Freeze out caused 151 deaths and over $18 billion of damage.

During the Freezeout, Houstonians came to the virtual community to seek help. The tenor of the community however, was noticeably different from that during Hurricane Harvey.

Identity

The virtual community during this disaster did not exhibit a clear collective identity. Instead, numerous fragmented identities appeared across the community. These included:

Samaritan: Samaritans offered help. Such help could come in the form of material assistance, advice or messages of support.

Havant [sp] lost power yet. Have been offering any and everyone a place to stay.

Wrong Samaritan: Some individuals were well-intentioned, but their advice was potentially harmful to Houstonians. For example, people living outside of Houston familiar with freezing weather advised Houstonians to open their taps a little to keep the water running.

I believe it's most important to drip your faucets- keeping some movement in the pipes prevents bursting.

This advice was not good for Houston. Cities used to coping with winter freezes typically employ aboveground water tanks; the siting of tanks above ground helps maintain water pressure. In contrast, Houston's water tanks are below ground such that if the water supply runs low (because everyone is dripping their faucets), water pressure decreases. Low water pressure allows underground contaminants to enter the water system, thereby contaminating the drinking water supply. Houston officials released several public announcements for disaster victims. They kept warning residents of Houston not to drip faucets.

Please do NOT drip faucets, this will cause lower water pressure. Houston's water system is different than other systems in that we don't use water towers to provide pressure to the system. We use ground storage tanks and pumps. Some of this equipment is damaged by the weather.

Authority Denier: A number of people both within and without Houston rejected statements by Houston authorities and encouraged others to reject such statements.

The mayor is a moron. Drip your faucets. Somehow, every other city, insurance company, plumber, electric company, etc. recommends dripping water but the city of Houston says it's a no go because our water system can't handle it.

To be fair, authority deniers had some basis for their rejection of statements from authority. A number of authority figures made knowingly false statements about the disaster during the disaster period, for example falsely blaming clean energy power systems for failing when in fact multiple kinds of power systems across Texas failed.

Governor Abbott and Rep. Crenshaw both immediately pulled the culture war nonsense, blaming windmills and the green new deal WHILE nuclear, coal, and natural gas generators were offline from the weather. THAT is over the top.

Authority Supporter: Authority supporters made statements in opposition to authority deniers.

City of Houston and other sources say that dripping doesn't do anything with our plumbing system compared to that of up north…literally says do not drip faucets on the city's emergency website.

Mocker: Mockers were identities that existed to insult Texas during the Freezeout.

Midwesterners here. You Houstonians are stupid. We get this every year. Chill the fuck out.

Falsehood Spreader: Falsehood spreaders were those who seemed to deliberately spread falsehoods about the Freezeout. For example, one common falsehood during the Freezeout was that windmills could not function in freezing weather, and the failure of the windmills caused the freezeout. To counter this, people posted images taken from the National Science Foundation showing the three windmills used to generate power in Antartica. Falsehood spreaders lied and said such images were photoshopped.

Photoshop. Wind turbines are fake news. They're props for fake liberal narratives. They don't even generate power.

Republican/Democrat: Although the above collective identities were not political in nature per se, in the United States there are two prominent political parties, the Republicans and the Democrats. This means there was some potential overlap with political identities, since the governor of Texas during the period was Republican, while the Mayor of Houston was a Democrat. For example, the Falsehood Spreader quoted below clearly identifies as a Republican as he mocks the (Democrat) former president Obama.

Thanks to Obama's ugly windmills we are out of power.

Governance

During the Great Texas Freeze Out, r/Houston experienced a spike of activity as Houstonians who were unfamiliar with dealing with extreme cold weather sought information on what to do:

I'm worried about the water pipes in my attic my water heater is also in the attic. Should running some faucets be enough to help prevent any frozen pipes or would it be best to just shut off water to the house tonight?

The r/Houston moderators noticed people created multiple individual threads asking for the same information (e.g., to drip or not to drip faucets). To minimize information overload, they decided to create a megathread following lessons learned from past disasters (e.g., Hurricane Harvey) (entrapped in past categories). They created one megathread for every day of power outage.

The initial megathread was insensitive to the plight of those without power. The moderators encouraged users to post irrelevant content such as pictures of dogs/opossums in a sweater, chili recipes and pictures of the skyline (automatic action). Although during routine times these kinds of content increase community participation, these were not appropriate during the freeze out.

Some things to post: Pic of your dog in a sweater, Pic of your opossum in a sweater, Chilli Recipes, Pictures of our beautiful skyline in this gloomy weather

As it became obvious the Freezeout was going to be a prolonged event, the tone of the megathreads began to become more serious. Hyperlinks to official sources in the description box of the megathreads were added. A link to a power outage tracker for Houston, links to boil water notices, a link to a list of disaster resources (e.g., donations) and links to warming shelters were also included. Moderators encouraged r/Houston users to post power outage information (including location), location of warming shelters and road conditions. This simply duplicated the idea of the megathread (entrapped in past categories).

Added helpful links up here…some things to post: If you lost power or got it back post time and zip, pictures of full grocery stores / empty shelves, any warming centers, road conditions.

Unlike during Hurricane Harvey, multiple collective identities formed, and the moderators did nothing to exclude any of these identities (automatic action). As a result, diverse and conflicting statements of fact and opinions spread across the r/Houston community. Many community members complained about conflicting information on the megathreads.

I've read so much conflicting information here [in megathreads]; what should I do?

Unlike during Hurricane Harvey, moderators failed to police the non-megathreads.

Hey mods: what's the point of this megathread if you are allowing all these snow pics in their own threads [individual threads]?

Although some r/Houston users expressed their frustration towards megathreads, the moderators continued using the same solution (fixate on a single perspective). These users preferred creating individual threads rather than seeking information from the megathreads.

Fuck off. This is life or death information, it doesn't need to be buried in a fucking megathread. God forbid a redundant post or two stays up in the middle of a weather emergency you piece of shit.

However, moderators had some basis for their continuation of using megathreads as they were successful during the hurricane. It became an established norm in the community that for

major events they would create a megathread to keep all the information in a single place. The following quote is an example of a user supporting moderators for creating megathreads.

For major events the mods [moderators] will create a megathread to keep all the important links, information and discussion in one place pinned to the top of the feed. They have established organization/systems in place

r/Houston users continued expressing their frustration with not getting accurate information. They thought megathreads were full of conflicting information. Moreover, they complained about the r/Houston moderators not taking any actions against problematic users which encouraged them to leave the community (fixate on a single perspective).

This sub is full of people bitching and mods do nothing. I'm out.

4.5 Discussion

Whereas diversity is normally vital for solving problems in virtual communities, our data demonstrates during a disaster diversity hinders problem-solving and putting people's lives at risk. Hence, this study has attempted to explore how and why this is the case.

Our answer is that when there is a *lack of goal consensus*, diversity causes interpersonal conflicts and prevents the virtual community from disseminating VAR information. Our findings suggest that virtual communities can overcome this problem by enforcing *transient partitioning* during the disaster. By transient partitioning we mean identification of one goal and exclusion of users with other goals from the community. Below we summarize the key points of our findings in Table 4.3.

Pre-mindful Hurricane Harvey	**Post-mindful Hurricane Harvey**	**Great Texas Freeze Out**
• Maintained established norms • Highlighted the constrained of the technology platform and ignored feedback from user • Allowed diversity and exposure to diverse opinions	• Recognized the limitations of existing routines and improved information dissemination process • Empowered those who demonstrated relevant expertise • Exhibited a cohesive collective identity with common goals	• Maintained established norms and unable to recognize the limitations of historical solutions • Exhibited multiple fragmented identities with separate goals

• Failed to develop goal consensus	• Excluded problematic users who had non-survival agenda • Controlled diversity of opinions • Developed goal consensus	• Unable to exclude problematic users who had non-survival agenda • Unable to control diversity of facts • Failed to develop goal consensus
Outcome: Unsuccessful provision of VAR information	**Outcome:** Successful provision of VAR information	**Outcome:** Unsuccessful provision of VAR information

Table 4. 3 Summary of findings

Figure 4.3 below synthesizes these findings into a framework, suggesting that the successful provision of VAR information in virtual communities during a disaster requires two factors: *(1) the presence of a cohesive collective identity*, and *(2) the presence of organizational mindfulness*. This combination creates goal consensus, which facilitates the successful provision of VAR information.

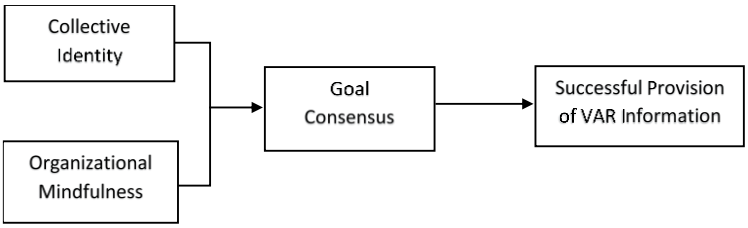

Figure 4. 3 Framework of VAR information provision during a disaster

The presence of a cohesive collective identity and organizational mindfulness

The three disaster episodes (i.e., Pre-mindful Harvey, Post-mindful Harvey, and Freeze Out) illustrate that multiple identities with different goals can emerge in virtual communities. However, our research suggests that a virtual community can only disseminate VAR information during a disaster if it acts collectively and mindfully towards a common goal.

In the pre-mindful Harvey episode, the r/Houston community was frequented by people from both in and out of Houston. The community welcomed diversity of opinion and the free exchange of information. At the onset of the hurricane, the community followed routine practices to exchange information. People created individual threads or commented on existing

threads. However, the community soon became overloaded with information - some accurate and some not. The community initially demonstrated organizational mindlessness by maintaining established routines during the hurricane. Community users continued to create individual threads or comment on existing threads, which made it difficult to find critical information. Although some users voiced their concern regarding the existing ways of disseminating information, most users primarily focused on achieving individual goals (i.e., seeking or providing information in a thread that fits their interests). The community did not act as a collective and failed to develop goal consensus. Additionally, the moderators highlighted the Reddit platform's constraints and ignored feedback given by community users. As a result, the community could not disseminate VAR information.

The post-mindful Harvey episode began when a community member from Houston suggested changes to existing practice to better facilitate the flow of VAR information. Moderators agreed to these practices (e.g., the creation of megathreads), which subsequently became institutionalized. Our data thus suggests necessary expertise was recognized and empowered during Hurricane Harvey. However, as the disaster progressed, the r/Houston community experienced interpersonal conflicts and the emergence of different collective identities. Individuals who resided in Houston during the hurricane or had an attachment to Houston identified as *'Houstonian,'* while helpful outsiders who had no connection with Houston (i.e., non-Houstonian Samaritans) were favoured over non-Houstonian non-Samaritans. The latter came with an agenda of propagating falsehoods, scamming disaster victims, insulting victims and political blaming. The presence of a dominant in-group with a goal consensus around helping people survive the disaster, however, allowed the community to identify these problematic outsiders. Community users developed shared norms such as attaching evidence to critical information to prevent falsehoods. The community monitored the threads and used Reddit's voting feature to indicate useful information resulting in useful

information gaining more visibility. They also developed sympathetically intimate relationships and acted as a collective to support each other. For example, they provided emotional support by posting messages such as 'stay safe.'

By contrast, in the Freeze Out, the community mindlessly followed established norms of creating megathreads, similar to what they did with Hurricane Harvey. The moderators failed to recognize the severity of the disaster and encouraged users to post irrelevant content such as pictures of dogs in sweaters. Unlike the post-mindful Harvey episode, the community could not establish mechanisms (e.g., shared norms of attaching evidence) to segregate falsehoods and VAR information. Numerous fragmented identities with divergent goals emerged in the community. For example, republican supporters blamed democrat supporters for wind power failures. No dominant in-group stood out. Hence, goal consensus was not achieved and the community failed to disseminate VAR information.

From the above discussion, it appears organizational mindfulness along with a cohesive collective identity can help communities develop goal consensus around helping with the disaster, allowing the community to disseminate VAR information. If virtual communities are mindful, they can better identify interpersonal conflicts more quickly. They can notice problematic users whose goals might not align with collective goals. And if virtual communities have a cohesive collective identity, they can provide better social support (e.g., emotional, tangible aid and service) during disasters.

The need for goal consensus

Previous research on virtual communities has suggested that diversity and exposure to diverse opinions are key for virtual communities to solve problems (Divakaran and Nørskov 2016; Yang et al. 2017). Research also advocates that diversity of goals and interests is a precursor for knowledge collaboration in virtual communities (Faraj et al., 2011; Safadi, Johnson, & Faraj, 2018). IS literature on disaster management also emphasizes the importance

of diversity for collective problem solving (Nan & Lu, 2014; Park & Johnston, 2017; Vieweg et al., 2008). We agree that in non-disaster situations, diversity is valuable in a virtual community and multiple goals are perfectly fine. Building goal consensus is not necessary.

However, during a disaster, having multiple goals potentially prevents people from receiving VAR information in a timely manner. Diversity can put disaster victims' lives at risk by preventing virtual communities from developing goal consensus. Our findings on the need for goal consensus echoes findings of extant disaster management literature exploring traditional disaster relief organizations (e.g., police, relief organizations, volunteer groups) (e.g., Bang and Kim 2016; Beck and Plowman 2014).

Mechanisms for building goal consensus

One unanswered question in the above discussion is what mechanisms (e.g., governance structures) a virtual community can provide so the community works in unity toward a common goal. Our data reveals one potential mechanism is for the virtual community to enforce transient partitioning- the community identifies and gives prominence to users with the favored goal and excludes users with other goals. We acknowledge the potential problems with this suggestion. Scholars generally argue that openness and inclusion are two key pillars for creating a successful virtual community (Pi, Chou, & Liao, 2013; Rheingold, 1993). Conversely, exclusion can limit users' ability to establish or maintain positive interpersonal relationships. Excluded users may experience negative emotions (e.g., anxiety, fear) and lower trust in others (Liu, Fan, Ji, & Jiang, 2020). Moreover, the community can suffer from 'cultural tribalism', in which a group of users choose to preferentially connect with each other, to the exclusion of outsiders (Dwyer, 2007). Research argues that cultural tribalism reduces cognitive diversity and limits a community's ability to solve problems (Arazy, Nov, Patterson, & Yeo, 2011).

However, our study suggests that, during a disaster, openness and inclusion can lead to a virtual community having contradictory goals. Although our proposed solution might be seen

as a shift towards authoritarianism, excluding problematic users is likely the best policy. For example, in the post-mindful Harvey episode, the r/Houston moderators only allowed Houstonians and non-Houstonian Samaritans to participate in the community discussion. When a community user did not behave according to community norms, they received tangible punishments like getting banned or muted. As a result, the community was united and acted as one strong collective to facilitate the successful provision of VAR information.

By contrast, in the pre-mindful Harvey and Freeze Out episodes, the moderators allowed everyone to speak freely regardless. Thus, falsehoods were not controlled. Although much advice was well-intentioned, much advice (e.g., drip water taps) was inappropriate for disaster victims. As a result, the community continued receiving conflicting and erroneous information.

4.6 Conclusion

Virtual communities are open spaces where diverse individuals interact and share information regardless of their geographic boundary. While diversity in a virtual community might be good under normal circumstances, during a disaster diversity can put people's lives at risk. We have attempted to show how and why diversity in a virtual community might hinder the dissemination of verifiable, accurate and reliable information during a disaster. Our findings reveal that during a disaster, goal diversity is not desirable in a virtual community. When the community supports goal diversity, it cannot build consensus around a common goal. Our solution is to suggest that organizational mindfulness along with a cohesive collective identity is required for building goal consensus around the dissemination of VAR information. Virtual communities need to engage in collective problem-solving efforts to counteract the problems associated with the dissemination of false and irrelevant disaster information. This means that a virtual community needs to identify one goal and exclude users with other goals from the community (at least temporarily).

We acknowledge various limitations of our research. First, we have studied one virtual community only and acknowledge that each disaster is unique. Second, we have only focused on two short-lived disasters. Our findings might be inapplicable to prolonged disasters (e.g., COVID-19). Finally, we only explored the disaster response phase of each disaster. It is possible our findings are inapplicable to other disaster phases (e.g., mitigation, recovery). Despite these limitations, we hope our attempt to generalize our case study findings to theory might be useful for other researchers.

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CHAPTER 5. CONCLUSION

Virtual communities play a significant role in disaster response by disseminating useful disaster information. However, they also suffer from an infodemic, making it difficult for disaster victims to find trusted information. Furthermore, they need to transform authoritative information into hyperlocal context. Hence, this thesis aimed to understand better how virtual communities can be managed effectively during disasters to generate and disseminate trusted information. Two natural disasters: Hurricane Harvey 2017 and, The Great Texas Freeze Out 2021, are the specific empirical examples used in this thesis to develop this better understanding. This thesis had three research questions, and each question is mapped to a chapter. This concluding chapter is organized in the following way: First, it presents the summary of findings, the theoretical contributions of each paper, and practical implications. Finally, the research limitations are highlighted, and some suggestions for future research inquiry are offered.

5.1 Summary of Findings and their Contributions to Theory and Practice

This thesis offers several theoretical contributions and practical implications. These contributions were discussed in each of the individual papers and will be summarized here. Table 5.1 summarizes the findings of the three papers.

5.1.1 Summary of Findings and Theoretical Contributions

First, the existing disaster management and virtual community research offers limited understanding of how sense of community (SoC) can be quickly constructed during a disaster. There are two theoretical streams (i.e., socialization and formal control) on forming SoC in virtual communities in non-disaster situations. However, how they relate to each other remains an open question. Paper I addresses this issue and develops a framework which is the principal theoretical contribution. It reveals two processes, *endorsing* and *disciplining*, interacting

between socialization and formal control, can together foster a SoC. Community members can inform moderators how emergent group norms work, transfer community feedback and introduce emergent leadership through the endorsing process. Concurrently, moderators can impose emergent group norms, sanction uncivil behavior and authorize emergent leaders through the disciplining process. Moreover, emergent leaders can act as a conduit between community members and moderators.

Second, prior studies fall short in addressing how virtual communities can quickly disseminate trusted hyperlocal information during disaster times while simultaneously suppressing false and irrelevant information. Paper II addresses this problem and reveals that virtual communities need to *(1) create a controlled information hub*, *(2) promote identity revelation*, and *(3) allow for temporary emergent hyperlocal leadership* to disseminate trusted hyperlocal information. Additionally, although IS research acknowledged risk society as a concept (e.g., D'Mello, 2005; Jacucci, Grisot, & Hanseth, 2004; Westergren & Holmstrom, 2008), to the best knowledge of the author, no one has applied it as a theoretical lens to leverage its key theoretical insights. Paper I suggests risk society theory (Beck, 1992; Beck, Giddens, & Lash, 1994) can be applied to virtual community research to understand the risk mitigation process during extreme events such as natural disasters.

Finally, Paper III presents unexpected findings and demonstrates how and why diversity in a virtual community hinders the dissemination of trusted information during a disaster. The results reveal that one key inhibitor of disseminating trusted information is the lack of goal consensus. The paper suggests enforcing transient partitioning, i.e., identifying one goal and excluding users with multiple goals from the community. The paper also attempts to develop a framework that suggests the combination of a cohesive collective identity and organizational mindfulness creates goal consensus. If the community acts collectively and mindfully towards a common goal it can facilitate trusted information. Williams, Gruber,

Sutcliffe, Shepherd, & Zhao (2017) called for further research regarding the link between crisis management and mindfulness. This paper provides one answer to this call by focusing on virtual communities' disaster information management process.

The insights derived from each paper are grouped into four themes to illustrate how they differ or resonate with existing studies. The four themes are: *(i) receptive to community sentiments, (ii) seek goal consensus, (iii) reverse the standard policies,* and (*iv) integrate emergent leadership*. These themes are discussed in detail next.

(i) Receptive to community sentiments: This thesis improves our understanding of how virtual community moderators can enhance group-level SoC and help generate trusted information. The expectations of a virtual community change significantly during a disaster. Research suggests misalignment of expectations among community users and moderators can create conflicts (Carey & Meyer, 2016; Petrovčič, Petrič, & Lozar Manfreda, 2016). If moderators are not receptive to community sentiments, they can pose risks of wrong enforcement, eroding individual's SoC and adopting ineffective practices to disseminate information. All three papers presented in this thesis suggest virtual community moderators should be receptive to community sentiments during a disaster. For example, in Paper I, moderators only became aware of emergent group norms once they participated in the community discussion and acknowledged community feedback. In Paper III, moderators failed to disseminate trusted information because they used historical solutions and ignored community feedback.

(ii) Seek goal consensus: This thesis contributes to our understanding of why diversity of goals can affect virtual communities during disasters. While prior virtual community research shows that diversity of goals and interests is a precursor for knowledge collaboration and problem-solving (Divakaran & Nørskov, 2016; Faraj, Jarvenpaa, & Majchrzak, 2011;

Safadi, Johnson, & Faraj, 2018; Yang, Li, & Huang, 2017), this thesis shows that is not always the case. Paper III, in particular, illustrates that having multiple goals potentially prevent people from receiving trusted information in a timely manner during a disaster. Hence, this thesis suggests sacrificing goal diversity and seeking goal consensus during a disaster. It argues a virtual community can only disseminate trusted information if the community acts collectively and mindfully towards a common goal.

(iii) Reverse the standard policies: The existing practices or policies to manage a virtual community may not be relevant or sufficient during a disaster. This is because disasters bring new, unprecedented requirements (Majchrzak, Jarvenpaa, & Hollingshead, 2007). Hence, the virtual community moderators may need to reverse established practices or policies to cater to new requirements. Existing virtual community research suggests openness and inclusion are the two pillars for creating a successful virtual community (e.g., Pi, Chou, & Liao, 2013; Rheingold, 1993; Yu, Lu, & Liu, 2010). When a virtual community supports openness and allows free participation, it can help the community thrive and retain individual-level SoC (Blanchard, Welbourne, & Boughton, 2011). However, this thesis suggests the opposite. It highlights the need for controlled participation, including isolating problematic users and favouritism towards hyperlocal individuals. Paper II provides details on how to create a controlled information hub. It highlights the importance of centralizing and curating information and attaching evidence for informational posts. Reversing the policies of openness and inclusion can help generate trusted information. For example, Paper I particularly suggests isolating problematic users can improve group level-SoC during a disaster. Paper III recommends isolating problematic users to minimize contradictory goals, which can facilitate the successful provision of trusted information.

Paper	Research Question and Theoretical Lens	Main Findings
1. Together We Survive: Constructing a Sense of Community in Virtual Communities during Times of Disaster	How can a sense of community be constructed and maintained in self-governed virtual communities during times of disaster? Socialization, Formal Control and Sense of Community	Constructing a SoC requires two factors: (1) socialization and (2) formal control. Two processes, *endorsing* and *disciplining*, interacting between socialization and formal control, can together foster a SoC. Endorsing can help channel emergent group norms, transfer community feedback and introduce emergent leadership. Disciplining can help impose emergent group norms, sanction uncivil behavior (isolate problematic users) and authorize emergent leaders.
2. From Chaos to Clarity: How can Virtual Communities Provide Trusted Hyperlocal Information during a Disaster?	How can virtual communities provide trusted hyperlocal information during a disaster? Risk Society Theory	Necessary institutions required : (1) A controlled information hub: centralization of information, curation of information and providing supporting evidence (2) Promoting identity revelation: allowing disclosure of personal information, facilitating identity signaling that reveals hyperlocality and professional status (3) Temporary emergent hyperlocal leadership: recognizing and cooperating with emergent hyperlocal leaders
3. How and Why does Diversity in a Virtual Community Hinder the Dissemination of Verifiable, Accurate and Reliable Disaster Information?	How and why does diversity in a virtual community hinder the dissemination of verifiable, accurate and reliable information during a disaster? Organizational Mindfulness/mindlessness, Collective Identity	(1) The combination of organizational mindfulness and collectively identity creates goal consensus which facilitates the successful provision of trusted information. (2) Multiple goals potentially prevents people from receiving trusted information in a timely manner. A virtual community should identify one goal and excludes users with other goals from the community.

Table 5. 1 Summary of findings for the three papers

Anonymous participation is another key hallmark of virtual communities. Existing research highlights several advantages of anonymous participation, such as ensuring safety against physical threats, cyber-harassment, social loafing and abuse of personal information (e.g., Connolly, Jessup, & Joseph, 1990; Prakasam & Huxtable-Thomas, 2021; Ren et al., 2012; Shiue, Chiu, & Chang, 2010). However, this thesis suggests anonymous participation is not always desirable during disasters. This thesis finds anonymity hinders individuals from receiving social and informational support at their specific location. Thus, this thesis suggests disclosing personal information (e.g., address) during a disaster. Furthermore, anonymity can contribute to the infodemic because anonymous individuals can spread falsehoods and detrimental information. Moreover, anonymity promotes scepticism. For example, Paper II found initially, people did not believe the information provided by a meteorologist until his real-world occupation was revealed. Therefore, this thesis suggests disclosing professional status and indicating hyperlocality. Taken together, identity revelation can foster trust in the provided information.

(iv) Integrate emergent leadership: Consonant with previous studies, this thesis highlights the importance of emergent leadership during a disaster (Comfort & Okada, 2013; Gardner, 2013). This thesis illustrates how emergent leadership can help overcome issues associated with trusted information dissemination. For example, paper I shows how emergent leadership relayed emergent group norms to the moderators. As a result, moderators improved information flow and SoC at the group level. While previous studies focus heavily on geographical dispersion and supports the ubiquity of leadership (e.g., Johnson, Safadi, & Faraj, 2015), paper II suggests leadership should be (at least temporarily) situated in a hyperlocal context during a disaster. Simply put, emergent leaders should be hyperlocal individuals. Furthermore, paper III illustrates how the emergent leader influenced the moderators to act

mindfully. Taken together, this thesis suggests integrating emergent leadership activities for effective disaster response and trusted information dissemination.

Collectively, these four themes can be used as guidelines to generate and disseminate trusted information where it is needed in times of disaster. Table 5.2 summarizes these four themes.

Receptive to community sentiments	• Virtual community leaders (i.e., moderators) should be receptive to community sentiments to learn emergent group norms and changing needs of the community.
Seek goal consensus	• A virtual community should discourage diversity of goals during disasters. It should act collectively and mindfully towards a common goal.
Reverse the standard policies	• Openness, inclusion and anonymous participation can be problematic during disasters. Hence, these policies may need to be reversed. A virtual community should be controlled and biased towards hyperlocal individuals. It should isolate problematic users (or at least prevents them from posting during the disaster). • It should centralize and curate information during disasters. While centralizing information, it may be beneficial to integrate authoritative information. • A virtual community may allow users to disclose personal and professional information. In addition, it should institutionalize the norm of attaching evidence for informational posts
Integrate emergent leadership	• Virtual community leaders should recognize emerging leaders, cooperate with them, and grant them appropriate power. They should give preference to hyperlocal leaders.

Table 5. 2 Guidelines for generating and disseminating trusted information during disasters

5.1.2 Practical Implications

During a disaster, a virtual community must be managed effectively to combat an infodemic and improve the spread of trusted information. This thesis provides some important practical implications for three stakeholders: (1) virtual community leaders, (2) emergency authorities and (3) system designers. These are described next.

Implications for virtual community leaders: First, Paper I suggests during a disaster, new group norms can emerge in the community. Hence, virtual community leaders (i.e., moderators) should actively participate in the community to learn its changing needs and emergent group norms. This will help virtual community leaders change existing practices and improve SoC at the group level.

Second, Paper II suggests virtual community leaders should centralize the flow of information and actively curate information. They should reverse the policies of openness, inclusion and anonymity. Reversing these policies will help combat infodemic, enhance social support and improve the spread of trusted information. Furthermore, they should establish new institutional practices that aggregate information from both authoritative and hyperlocal sources. They should also establish the norm of attaching evidence for informational posts.

Finally, all three papers suggest that virtual community leaders should recognize emerging leaders, cooperate with them, and grant them appropriate power.

Implications for emergency authorities: During disasters, people require information from emergency authorities. People generally believe in information if that originates from official sources. Moreover, official information can help members debunk falsehoods. However, the existing ways of aggregating official information from multiple sources are time-consuming and not straightforward. By contrast, disaster is time-sensitive and requires a quick response. Hence, Paper II suggests that emergency authorities should make official information easily accessible to virtual communities, e.g., through an open application programming interface (API).

Implications for system designers: All three papers highlight the importance of identity revelation. Hence, this thesis suggests virtual community platforms would benefit from implementing features that signal information providers' identity (e.g., location, professional

status). Furthermore, community platforms should include features to identify potential hyperlocal leaders and facilitate their contributions.

5.1.3 Limitations and Future Work

As with all research, this thesis has limitations. First, the empirical support of this thesis' findings is limited to a single virtual community in Reddit. Other communication platforms with different technology features may yield different insights.

Second, this thesis presents only two short-lived natural disaster scenarios and focuses on the disaster response phase. The author acknowledges that each disaster is unique. Hence, the findings of this thesis maybe inapplicable to man-made (e.g., terrorist attacks) or prolonged natural disasters (e.g., drought, covid-19). Furthermore, the findings maybe inapplicable to other disaster phases (e.g., mitigation, recovery). However, the objective of a case study is not to generalize to a population but rather to either develop concepts, draw specific implications, generalize to theory, and contribute to rich insight (Lee & Baskerville, 2003; Walsham, 1995). Further studies are needed to confirm or negate these findings.

Third, this thesis did not consider *'culture'* as a contextual factor that might affect the information exchange behaviour of the community members. The thesis covers only one country. However, research suggests different cultures can affect patterns of online knowledge sharing (Atsawintarangkun & Yuizono, 2014). Hence, future research could further investigate disaster incidents from other countries discovering how culture affects information sharing behaviours in virtual communities during disasters.

Fourth, this thesis used only digital trace data. Future research can use other data collection methods such as survey, interview, and participant observation to confirm or negate the thesis findings.

Finally, the author acknowledges that other theoretical perspectives could be employed to the phenomenon under study. For example, structuration theory (Giddens, 1984; Orlikowski, 2000) and affordance theory (Majchrzak, Faraj, Kane, & Azad, 2013; Strong et al., 2014) could be used. However, the choice of a theory depends on the fit with the research problem under investigation (Myers, 2020; Walsham, 2006). Researchers should choose a theory that has the potential to provide rich insights.

5.1.4 Ethical concerns

The recommendations made in this thesis raise a few ethical concerns. During times of disaster, some virtual community members might need to sacrifice anonymity and reveal personal information in order to save themselves and/or enhance trust. In a life-or-death situation, survival is more important than maintaining one's privacy. However, we acknowledge one potential problem of this recommendation: once enacted, this policy is irreversible. Once personal information is propagated on the Internet, it continues to live long after the disaster has finished. Even if someone changed their username, it might be difficult if not impossible to regain one's privacy. However, in the particular case the community did not force members to sacrifice anonymity. Rather, community members were given a choice. But this choice was constrained by the nature of the disaster itself, with there being no practical way to rescue someone without knowing their exact location.

The thesis also suggests that the virtual community moderators should be able to monitor and curate the information during a disaster. The restructuring of information flows makes it easier for everyone, moderators included, to identify information salient to the crisis at hand. By definition, this makes non-crisis related information and fake news less visible. It could be argued that the author is encouraging a form of censorship, violating community members' right to free and open communication. However, if it comes down to a choice between open access and protecting human life, the author believe that the latter is surely more

important. Furthermore, this thesis suggests isolating problematic users. One could argue that isolating users can lower community engagement. However, one bad apple can spoil the bunch. Hence, the author believe problems should be nipped in the bud.

5.2 Final remarks

Natural disasters pose significant threats and challenges to our society. During disasters, people need trusted information about the disaster, its extent, and potential impact. Furthermore, they need hyperlocal information in a timely manner. When traditional sources fail to provide such information, people often turn to virtual communities to seek or provide information. Although virtual communities are valuable sources of useful disaster-related information, they are not a panacea. Community participants deliberately or unintentionally propagate falsehoods and irrelevant information, leading to an infodemic outbreak. Virtual communities can worsen a disaster victim's situation if not managed properly. Furthermore, the existing practices or policies of managing the community and disseminating information could be wholly inappropriate during disasters. This thesis prescribes some suggestions for virtual community leaders, emergency authorities, and system designers to address this complex problem. Besides, this thesis also contributes to a highly relevant yet relatively underexplored area of research. Collectively, this thesis suggests that receptivity to community sentiments, seeking goal consensus, reversing the standard policies, and integrating emergent leadership are keys to generating and disseminating trusted information during a disaster. In closing, it is hoped that the findings of this thesis might be useful for other researchers and could encourage IS scholars to advance this emerging area of inquiry for the betterment of our society.

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