Orchestrating through Whirlwind: Identified Challenges and Resilience Factors of Incident Management Teams during Hurricane Harvey

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While resilience in emergency management has been studied at the macro- (government) and micro-levels (individual field responder), little is known for resilience of incident management teams (IMTs). To investigate challenges and resilience factors of IMTs, this paper documents thematic analysis of 10 interviews with emergency personnel who responded to Hurricane Harvey in 2017. Themes emerged in four categories: goals, challenges, resilience factors, and technical tools of IMTs. Given similar goals but unique challenges during Harvey, IMTs sought to establish and maintain a common operating picture to make sense of evolving situations and make decisions adaptively. Various technical tools were used providing different functionalities, but a need for technology to reduce cognitive load was indicated. Findings of this study will inform the development of more resilient IMTs in future disasters.

INTRODUCTION

When a large-scale emergency incident occurs, individuals with various duties and expertise often form multi-disciplinary incident management teams (IMTs) in a collocated facility. IMTs are responsible for making sense of rapidly evolving situations and making decisions to allocate resources and adapt plans for upcoming operations. Collective sensemaking occurs through collection, evaluation, and dissemination of incident-related information, which then becomes a basis for team decision making (Son et al., 2018). IMTs take coordinated actions in conjunction with other individuals or teams for the sense-making and decision-making activities (Militello, Patterson, Bowman, & Wears, 2007; Smith & Dowell, 2000).

In case of an emergency, IMTs generally operate with limited resources (e.g., time, supplies, finance) and inaccurate or incomplete information, limitations which likely make pre-established plans ineffective (Perry & Lindell, 2003). Multiple factors challenge an IMT's objectives during a disaster, including the sudden onset of the emergency, the propensity for large consequences, and accompanying risks and time pressure. To address the standing challenges associated with incident management, research has focused on resilience, a system's ability to adjust its performance to changing conditions so that the system can remain functional (Boin, Comfort, & Demchak, 2010; Hollnagel, Woods, & Leveson, 2006). Research efforts have been largely made from macro-, micro- and meso-levels. At the macro-level (e.g., government), researchers examined the etiology of crises and emphasized the need for a resilience framework for emergency management policy and administration (Boin & McConnell, 2007; Harrald, 2006). In this regard, some studies shed light on the flexibility (or lack thereof) of incident management protocols such as Incident Command Systems (ICS) and National Incident Management Systems (NIMS) (Bigley & Roberts, 2001; Buck, Trainor, & Aguirre, 2006; Perry & Lindell, 2003). Studies at the micro-level have examined how individual responders adapt or improvise their behaviors. For example, Webb (2004) and later Webb and Chevreau (2006) investigated how individual responders adapt roles, tools, and facilities to meet goals given during an emergency. Furthermore, adaptation is found to be more prevalent in following procedural behaviors than in material usage such as equipment and location (Mendonça, Webb, Butts, & Brooks, 2014). At the meso-level of incident management where IMTs operate, some studies investigated team aspects such as collective sensemaking. For example, Weick (1993) identified that collapse of sensemaking in a firefighting crew led to loss of resilience in coping with unexpected events. Comfort (2007) emphasized the need for a 'common operating picture (COP),' shared information among different organizations essential to adapting their performance to evolving situations. In addition, adaptations occurring in a team or organizational setting have been studied in the context of emergency management. For instance, Kendra and Wachtendorf (2003) observed how multiple IMTs reestablished a destroyed Emergency Operations Center (EOC) following the September 11 disaster and identified resilience traits including goal-directed and solution-seeking behaviors. This body of literature commonly found that IMT resilience is crucial in unexpected situations.

Despite the important role of IMTs in making emergency operations resilient, IMTs have not been analyzed in as much detail as the micro-/macro-levels. In particular, IMT operations under a real-world incident, regarding what makes the IMT resilient or brittle, have been rarely investigated. Conducting interviews with IMT personnel involved in the management of Hurricane Harvey, this study aims to elicit factors of resilience of multidisciplinary IMT s in action. Findings from the study may further expand our understanding of what challenges IMTs are faced with and also inform future improvement of IMTs' emergency response capabilities, including technical supports and work procedures.

METHOD

Data were collected through semi-structured interviews with 10 government emergency personnel (nine male and one female). The average age (SD) of the interviewees was 51.6 (10.1) years and their average career in emergency service (SD) was 21.9 (6.4) years. The interviews were conducted

February-July 2018. To account for comprehensive perspectives of an IMT, interviewees were recruited from various functional disciplines (e.g., Command, Operations, Planning, and Logistics) from different organizations. The study was IRB-approved, and prior written consent was obtained. Interviewees were first asked to provide brief professional career such as past experience and roles performed during Hurricane Harvey. Based on this initial information, the interviewers asked a series of questions that covered challenges encountered during Harvey, processes and technologies for information management and communication, key decisions made, and procedures and plans followed. Interviews were audio-recorded and transcribed by an automated transcription service (Temi, 2018) and then manually corrected by the first author. Using MaxQDA Analysis Pro (VERBI Software, 2018), a thematic analysis was performed to capture emerging themes among the qualitative data (Braun & Clarke, 2006).

RESULTS

Qualitative analysis of interview data produced themes under four high-level categories (Table 1): i) goals and priorities of the IMTs, ii) unique challenges to the IMTs, iii) resilience factors of the IMTs, and iv) use of technologies in the IMTs during Harvey. Quotes supporting the findings are presented in *italics*. Core elements of the findings extracted from the quotes are in ***bold***.

Table 1. Categories and themes from the interviews

Category	Theme
i) Goals of the IMTs	• Life safety • Mass evacuation • Operational planning and guidance
ii) Challenges to the IMTs	• Uncommon damaging pattern • Massive and unanticipated needs for resources • Unrealistic expectations and unimplemented measures
iii) Resilience factors of the IMTs	• Establishing and maintaining COP • Making adaptive decisions • Balancing between efficiency and thoroughness • Lessons learned from past experience
iv) Technical tools for IMTs	• Different functions supporting COP, decision-making • Needs for better technologies to relieve cognitive load

i) Goals and Priorities of the IMTs during Harvey

The most crucial goal of the IMTs during Harvey was to ensure life safety of the public, including search, rescue, and mass evacuation to shelters. In achieving these goals, timeliness or quickness of incident operations after the hurricane was considered a priority of the IMTs.

> ***Our priority is LIPS****, right?* ***Life safety****, incident stabilization and societal restoration and [...] property protection. So* ***'L' is first****.* ***'L' is always first and that's how we drive our priorities.***

> *[…]* ***Again, going back to the life safety, time is a key.***

However, IMTs differed from field responders in achieving the goals. While field responders focused on tactical activities to deal with on-scene events, IMTs were more concerned with operational management that plans and guides tactical actions.

> *I don't worry about today.* ***I always worry about tomorrow****. […] We make sure that we have the resources that we put an incident action plan together so that they fall into the next operational period.* ***If we get sucked into tactics in an operation center, failure is inevitable.***

ii) Unique Challenges to the IMTs during Harvey

In pursuing the goals of the IMTs, there were several unique challenges associated with Harvey. First, Harvey exhibited uncommon patterns of damage, impacting large areas and infrastructure as it moved along its path.

> *So,* ***there's really four incidents, right? It's not just one incident, right?*** *So you got to [a city] and then the costal main strip, you've got all the southern coast. It started to get flooded immediately. Then, you've got the [another city] section […].*

> *[…]* ***the flooding was like, 300 miles, 39 counties. It was across 1,777 square miles*** *[...] where we received over three feet of rain in less than four days.* ***95 percent of your infrastructure is under water.***

Second, Harvey brought some specific threats such as torrential rainfall and high winds. The most aberrant trait of Harvey was its traveling path and consequent tremendous amount of floodwater.

> *It hit a cold front, a very, very strong cold front, and* ***stayed stationary for a very long period of time****, almost 36 to 40 hours and* ***then it went back out to the coast and then it came back*** *in and it came back in twice.*

> *So one of the most stressful times in my entire life was to say, I honestly don't think it's a good idea for us to evacuate because at the time [...]* ***Harvey was projected to come inland and then keep going to the [evacuation] area.***

Third, the abnormal travel path of Harvey resulted in massive, unanticipated demands for resources. While IMTs were supposed to work on mutual aid between neighboring jurisdictions, Harvey imposed overwhelming needs on many of the IMTs, preventing mutual aid between them.

> *Well, the need was great.* ***We found that the first responders*** *[…]* ***had leaned on their mutual aid*** *[but the mutual aid]* ***was not available because everybody was responding.***

We had to adopt and adapt because [a neighboring jurisdiction] lost their radios, so, not radio, but their 9-1-1 was overrun. ***So, we had approximate 3,000 calls rolled over to us. Out of those 3,000 we had 457 rescues****, water rescues that were outside of the [jurisdictional] area.*

Fourth, the IMT personnel did not expect scenarios that unfolded during Harvey, and the impact of such "unrealistic expectations" were exacerbated when planned actions such as sheltering were not implemented:

So that to me is the biggest problem with unrealistic expectations. *[…]* ***[T]hey are assuming it's going to be quite the stereotypical storm. When in fact it wasn't.***

The other problem we had was the hundred and 20 shelters that were supposedly established. […] ***There was nobody there. There was no water. So, we had people standing outside the shelter and it wasn't a shelter.***

iii) Resilience Factors of the IMT during Harvey

Given the challenges faced by the IMTs during Harvey, the IMTs sought to remain resilient to achieve their goals. First, the IMTs pursued collective understanding of the changing situations called 'common operating picture' (COP). Based on the COP, the IMTs made decisions to adapt their operations to the changing conditions and newly-arising events.

The COP provided a snapshot of evolving situations and consisted of various types of incident data which formed the basis for decisions and subsequent actions. However, in erratic situations, the COP changed according to the tempo of an event. To keep up with the rapid tempo of situations precipitated by Harvey, several efforts to establish and maintain the COP were identified, including regular briefings and teleconferences.

So now that gives me ***a snapshot*** *and under that SWEAT [security, water, energy, accessibility, and tele-communication] report it breaks out into multiple categories. […] Now I can do* ***a snapshot of a jurisdiction and know now who's in trouble.*** *[…] So* ***I can make good strategic decisions based on resource allocations based on what we're seeing in the reports.***

We try to give a common operating picture based on what we know right now so that we have a saying: ***Wait seven minutes and it'll change****.*

And ***the briefings really are the most action-packed information.*** *You're gonna have the most information for us, those two briefings because that's the boss gets his crystal ball out and sees this what we think are going to happen today […]*

There was a difference between collective and individual awareness of the situations. In practice, the IMT personnel indicated that COP is a broad picture of what is going on, whereas situation awareness is an individual understanding of particular events each person deals with.

I think ***the common operating picture is more on the grand scale*** *and* ***the situational awareness is on the*** *[…]* ***individual scale.***

The IMTs were also collective decision-makers during Harvey. Interviewees emphasized the needs for being flexible and adaptive to satisfy unique challenges of Harvey.

We're very flexible*. I mean, if you're,* ***if you're rigid in your decisions and your thoughts, you're going to break.*** *You got to be; you have to be able to adapt.*

As indicated above, IMTs had to adapt plans and processes. Successful adaptations, in which the IMTs had departed from pre-established plans, include decisions to assign field responders as points of distribution, and to use food trucks and local schools for feeding and sheltering evacuees.

I want them to be able to hand them food and water and be first contact. So ***we created a new process within the point of distribution plan that we had not done before, but we adapted.*** *So we are points of distribution.*

The problem was our caterer was setting up at the time and knowing the massive scale we needed, they were taking longer. So then my boss [...] had ***an idea that we want to get food trucks right to come in and feed us.***

And then ***we added the ISD [independent school district] onto it because the schools ended up being a big part of the sheltering by itself.*** *[…]* ***it came as impromptu shelter or like a refuge.***

In addition, the IMTs involved community resources in rescue operations. In principle, the IMT's incident action plans do not take non-government resources into consideration due to issues associated with credentialing non-professional resources (Federal Emergency Management Agency, 2017). Once such a decision had been made, the IMT simplified the credentialing process by asking only for essential information.

I think ***Harvey took thinking outside the box to a totally new level*** *[...] [I]f you look at [a jurisdiction's official] and [an IMT commander] when they made the decision to basically say,* ***'you know, we can't handle this, we need to ask for citizens to bring in their boats.'*** *I think that was probably* ***the number one decision that saved more lives than anything else.***

[…] I want to tell these civilians that are in the area to call into [...] the call center. We're going to grab ***four sets of data****. I want their* ***name, phone number****, I want*

what kind of resource *they have and* ***where they're at right now****.*

Our interview revealed the IMTs strived to strike a balance between efficiency and thoroughness because of the trade-off between the two. In search and rescue operations during Harvey, three-tiered search strategies were employed: a hasty , a primary, or a secondary search (in order of decreasing efficiency and increasing thoroughness).

[…] ***The hasty searches****, what we originally do when we're out there trying* ***to pull people out of the water****, right? That's a hasty search.* ***There was nothing organized about it****. […]* ***A primary search*** *is much more organized and* ***it takes longer****, but* ***a secondary search*** *means we're going in and searching every single building.* ***It's going to take a ton of time.*** *So, we give the jurisdiction those* ***a la carte menus*** *and we say, which one of these do you pick?*

Moreover, our study identified anticipation a s key to adapting resource allocation. By anticipating future incident status, the IMTs were able to operate proactively rather than reacting to requests for help. Lessons learned from previous hurricanes played an important role in adapting decisions preemptively during Harvey.

So, ***I have to forecast****. […] we would never deploy assets into an incident because I know what the water's about to do. So,* ***let me pre-positioned them before I can't get them to you.***

And trying to ***stay ahead of the storm,*** *right? I mean a big part of it is* ***knowing which resource is going to be needed next and trying to get people there as quickly as you possibly can, even if you aren't asked.***

[…] ***in 2015 and 2016 our northwest fire departments learned that.*** *So, when Harvey hit, they were so* ***much better prepared to manage Harvey*** *than all of our departments on the east and the south side […].*

iv) Technical Tools in the IMT during Harvey

In order to manage ample, volatile information and to make high-stake decisions, the IMTs utilized various technical tools including common information communication technologies as well as incident information management software. Although each tool had its own functionalities, some tools were preferred over others because the tools provided more useful functions in a specific context. For example, text messaging was helpful in ease of use and traceability of data as well as in communicating visual information such as photos.

I texted him more often than I phone-called *because it seemed like the text has got the information that, you know,* ***they could look back at it all the time****. […] Especially for the young folks. The young folks, I figured that out really quick.* ***Don't even call them on the radio, just text them because they'll respond.***

So ***photos were used for the text****, you know, 'Send me a photo of how that is at this location.' Boom. Okay. Wow. There's one there and now I'm, you know,* ***we can now adjust our operations based on the information and photos do a great job of providing the information****.*

Although text messaging was widely used during Harvey, other technical tools and incident management applications performed their requisite functions. For instance, incident information management software was prevalent as it helped collect and integrate multiple data from different sources. Emails and social media worked better than text in dealing with larger amount of data and rumor control, respectively.

Well, I mean we have ***computer systems that are helping us collect all that data and bringing it in****, but it really relies on, it still relies on personal contact.*

Email would be… ***our big things for email would be the conference call information****. So many* ***pictures*** *and* ***photos****,* ***pictures on text****, but* ***it works great if you do it on an email.***

And the third piece, which probably didn't happen to anybody was social media, ***social media****, which is probably the most, I guess … for us it was like* ***the rumor control****.*

While different technologies benefitted the IMTs in handling and communicating volatile information, persistent issues related to cognitive loads were also identified. Additionally, the IMT personnel were cautious about technical failure and thus stressed the redundancy of technologies:

So, I got this thing about digestion. Okay, ***I don't care how much data you collect. I can only digest so much.***

We are redundant as possible. *[…] [Y]ou do your job with* ***a chief tablet and pencil*** *because that's what you have to be able to fall back to.* ***If we don't train to that level, we will fail.*** *[…]* ***we can't become dependent upon it because someday technology fails. Technology always fails.***

DISCUSSION

The findings of this study suggest that the goals and priorities of the IMT are not dissimilar from other disasters with respect to designated purposes of the IMTs (Chen, Sharman, Rao, & Upadhyaya, 2008). However, the interviews with emergency operations personnel deployed during Harvey offer deeper insight into the unique challenges the IMTs had to cope with. Although the IMTs in the affected areas were better prepared to tackle the hurricane and flooding

events, the abnormal hurricane path and unprecedented rainfall required the IMTs to adapt their performance to unpredicted events.

Given the unique challenges of Harvey, this study provides additional, recent evidence suggesting the need for resilience during a disaster (Boin et al., 2010; Boin & McConnell, 2007). Also, as indicated in a previous study (Bigley & Roberts, 2001), incident management protocols served as guiding policies while allowing the IMTs to be flexible. This paper suggests several indicators of resilience in IMTs. Aligned with the findings of existing literature (Comfort, 2007), shared understanding of situations or COP in the IMTs is considered critical to adapting their performance to rapidly changing conditions. Furthermore, this study presents diverse practical dimensions of the COP in the IMT such as integrated and collective knowledge, and as an information technology (Wolbers & Boersma, 2013).

This study also presents some beyond-the-textbook adaptations the IMTs made during Harvey. These adaptations suggest that the IMT personnel's past experience and anticipation based on such experience is a key to creating a new decision. Additionally, this study provides a characteristic evidence of resilience, that is, efficiency-thoroughness trade-off (Hollnagel, 2009) embedded in emergency operations.

Finally, this study highlights various technical tools used to support the management of complex information and adaptive decision-making in the IMTs. Nonetheless, which tools are chosen for use is based on individual members' preference without much regard for the IMT's integral information management perspective.

Some limitations should also be acknowledged. First, personnel interviewed in this study were recruited from multiple IMTs to obtain comprehensive knowledge. Thus, the findings presented in this paper may not be an assessment of individual teams that each interviewee had worked for. Second, while incident management protocols (e.g., ICS, NIMS) practiced by the IMTs were designed for all-hazards scenarios, findings from Harvey may not generalize to other instances or types of disasters such as man-made incidents.

In conclusion, this research has shown that the IMTs during Harvey experienced unforeseen challenges, but also showed resilient performance to overcome the challenges. Unlike individual first responders working at the front lines, the IMT's resilient performance emerges through collective sensemaking and adaptive decision making, mediated through various information technologies. If problems with associated technical tools are addressed, and adapted actions are reflected in incident management protocols and training programs, the IMTs will be better equipped with strategies and technical supports and thus function as a resilient team in future disaster events.

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