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The Technology Crisis in US-based Emergency Management: Toward a Well-Connected Future

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Abstract

For many years, CI has tried to show the value of computational techniques for response to hazard events but has yet to see success outside of post-hoc analyses. Meanwhile, emergency management (EM) has been struggling to cope with the impact of computation. This duality wherein we know technology can be useful yet also complicates EM (and has not yet been fully integrated into EM) is what we dub the technology crisis in EM. To begin to address this crisis and revitalize CI, we argue that it is necessary to develop an inventory of what technologies EM is competent with and to design training that can extend that competency. This research reports a survey of EM Practitioners in the United States. We offer one of the first inventories of EM technologies and technological skills and identify how current EM technological integration issues are a crisis.

1. Introduction

How we define and think about natural disasters is a concept in motion. Prior definitions centered on the events themselves as cause of disaster. However, in recent years, the field of emergency management (EM) has embraced the maxim, "there is no such thing as a natural disaster" [1–3]. According to this maxim, disasters are the result of a lack of human oversight in preparing for hazard events that could effect the locale. In addition, there is a growing frequency of technological hazards (a loss of control) like ransomware that must also be prepared for. Quite often, these technological hazards will occur when EM is responding to a natural hazard [4]. The question of technology and its uses in the midst of response to these hazards is increasingly important.

The importance of technology in response to hazard events begins *before* a hazard event occurs. It is before the event because when a hazard event occurs, residents will use their information communication technology (ICT) (e.g., smartphones, computers, social media) to ask for help. And yet, within EM practice there is an expectation that residents will request help through plain-old telephone services (POTS) because all levels of EM have not yet integrated the broad range of ICTs used in crisis with practice. We dub this chronic issue the technology crisis in US-based EM.

This crisis is best understood through a 2019 report from the US Office of the Inspector General (OIG) that details the Federal Emergency Management Agency's (FEMA) technical deficiencies [5]. These deficiencies are chronic and continuing to worsen. The issue begins with a lack of authority given to IT managers in EM agencies and is exacerbated by the growing frequency of events paired with consumer technology adoption trends. Other aspects of the issue include an inability to model, analyze, or understand the risk of non-white and low-income populations [6–8]. The OIG focused on federal agencies but the results can be applied to any level of agency resulting in a description of EM practice being at odds with consumer technologies [9–12]. Much of this lack of success can be attributed to a lack of "technical competency [13]"–or a lack of knowledge or understanding of technology–within EM in general.

From the technology side, crisis informatics has had issues with deploying technology for EM [10] and the current state of EM cannot be treated as just another sector to innovate in. To design tools for EM is to design tools for a stark landscape that is disconnected from electricity, running water, and rarely has more than an unreliable internet connection. Designing for EM will require a level of understanding that human-computer interaction (HCI)–the explorations of how technology mediates our experiences in everyday life–has rarely been forced to develop.

The present research focuses on how to begin to address the lack of ICT integration with EM practice. Despite over 20 years of attempting to offer tools and techniques to EM practitioners, crisis informatics (CI) – the study of information flow during disaster – has yet to achieve any level of success [10, 14].

The present research is organized as follows. First,

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we discuss the Incident Command System (ICS) as this is what CI will need to understand in order to insert technologies, training, and bureaucratic structures. Next, we expound on the background of CI and EM through the data's influence on disaster. After the background, we discuss our survey structure and creation. Finally, we analyze, discuss, and make conclusions about the results of the survey.

1.1. The Incident Command System (ICS)

Understanding the sociotechnical work present in EM is a key in developing better future technologies and solutions. In the US, the term an *incident* is used to signify – "An occurrence, natural or [human-]made, that necessitates a response to protect life or property..." [15, p.65]. Incidents are responded to using the the Incident Command System (ICS) which is part of the National Incident Management System [15, 16].

This is a top-down hierarchical system. Each person in the hierarchy has a designated task, a designated commander, and a chain of command with a *single* commander. Each incident has either a single Incident Commander, which is typical of smaller-scale incidents, or a group of people that function as Unified Command which is typical in larger scales or events that cross jurisdictional boundaries. By default, all incidents include a Command branch (i.e., Incident Commander or Unified Command); the largest incidents will include branches to cover:

- Operations performs plans using available resources & intelligence, while providing situation awareness to Planning and Logistics;
- Planning collects information & makes choices for the next operational period [17];
- Logistics focuses on personnel, equipment, and supplies; and
- Finance/Admin deals w/purchases and payments.

Thus, ICS provides an organizing structure for EM practitioners to internalize [15]. Of particular interest is not IT that falls under ICS's responsibility, but IT that should be *everyone's* responsibility.

2. Background: Disasters of and Because of Data, IT, or ICT

The study of ICT use by victims seeking information during EM response emerged throughout the 2000s. The initial research of ICT use during crisis originates during the 2001 World Trade Center attack around the technologies used by those trying to escape [18]. This study became CI after the 2007 Virginia Tech shooting as researchers examined how students maintained awareness of the situation via email [19, 20]. The gap between these events corresponds with the spread of internet culture, mobile devices, and social media. How these data impacted EM is contextualized by the time the event occurs, where it occurs, who it occurs to, and how much public and press involvement there is.

One of the most important reasons to better integrate technology with EM is the increasing frequency of disasters of and because of data. For example, early warning messages are an essential tool for EM. Even if the messages are sent within seconds of an event, those seconds can save lives [21]. And yet, messages have lost much of their potency due to mobile devices and new sources of information available through them.

While access to more information is generally beneficial, it has enormous consequences when attempting to warn the residents of an area about to be overwhelmed by an event like a tsunami, earthquake, storm, or tornado. This is sometimes referred to this as the "verification pause" [21,22] or "milling about" [23]. The pause to verify and its consequences can be seen in the events surrounding the Joplin Tornado of 2011 [24]. During the storm, alerts were sent to residents who lived where the tornado was going to strike. Instead of reacting, residents sought to verify that the tornado was indeed coming toward them and, in some cases, were caught in the destruction and lost their lives [24,25].

While only a year later, social media use during Hurricane Sandy has been the subject of repeated inquiry [26–33]. In 2012, Hurricane Sandy skipped along the east coast of the US, killing over 200 people and causing over $70 billion dollars of damage. Due to the size of the impacted area, researchers were able to evaluate how residents felt before, during, and after the event [34–37]. Municipalities had time to evacuate citizens and prepare for the storm's arrival. As the storm spread, purposeful spreading of misinformation on social media caused confusion and disruption [38, 39].

Finally, we discuss one of the most important aspects of the technology crisis in EM. In the context of the Boston Marathon Bombing in 2013, immediately after the detonation, online communities took two notable actions while local EM worked to stabilize the area. The first was to find shelter, food, and water for those stranded in Boston post-event [40–42]. Local blogs, *The Boston Globe*, and civic-oriented software helped to identify where official and unofficial shelters could be found [40, 41]. The second action was to help investigators comb through petabytes of text-based tips, images, and movies in or around the areas of detonation [43–45]. Here, the online communities that participated first action engaged the data created by those near the finish line at the request of the FBI [43, 46].

The resulting confusion hurt public perception of federal investigators and EM but caused crowdsourcing investigative efforts to lose public support. Despite losing public support, crowdsourcing efforts by emergent groups continues to grow and adjust according to criticisms and issues per event [47]. EM, on the other hand, has continued to struggle.

Since 2013, automated misinformation has altered everything from political races to trust in public safety officials [44, 48, 49]. The troubles present in sending alerts shown by the Joplin Tornado [50], an inability to fight automated spreading of online rumors [38, 44, 51], and an additional inability to integrate online communities in response efforts like Hurricane Sandy [52] or the Boston Marathon Bombing [47] have not been solved. This has led to the public groups like the "Cajun Navy" travelling to disaster-affected areas to help those who signal for help on social media, against the wishes of EM [53].

The release of the OIG report [5] indicates that not only has nothing been done, there are no processes in place to allow federal EM to start a process that would allow them to recover or correct the issue [5]. This has been especially problematic given two specific recent events: Hurricane Maria (2017) [54] and the west coast forest fires of 2020 [55]. In Hurricane Maria, FEMA had issues with a lack of enough satellite phones, a depleted supply chain, and inadequate logistical measures to re-supply Puerto Rico. All of these issues resulted in a loss of almost 40% of the supplies meant to help Puerto Ricans recover from Maria [5].

These issues have been exacerbated by new tools meant to provide better coverage, tracking abilities, and messaging to people about to be impacted by a disaster event. The most recent example is the 2020 west coast wildfires, wherein software would not work due to a programmer's error on a live product meant to be able to broadcast alerts [56]. Other software for alerting used out-of-date maps resulted in evacuation alerts for areas where no evacuation was necessary [56]. Cell phone technologies were also responsible for missed phone calls due to quiet mode or vibration settings that cannot be overridden in emergencies [57].

Finally, a recent report from the RAND corporation highlight a number of issues related to data and practice [58]. RAND researchers note that each new disaster brings new constructs, programs, and funds and this makes EM harder to understand. This, in addition to issues related to not using valid constructs to measure equity and risk [59], highlight the increasingly fragile ecosystem of response, one whose fragility resides in a lack of technological competency. While this background section has highlighted these issues, the present report is being used to re-configure the "Next Generation Core Comptencies" of EM [13] so that many of these issues can begin to be addressed.

3. Method and Data

In order to understand the breadth of the tech crisis in EM, we deployed a computer science education (CSed) instrument created to inventory the technical capacity of new computer science students [60]. This validated instrument was edited to apply to EM with the help of the Emerging Technology Caucus (ETC) of the International Association of Emergency Management (IAEM). We were able to do this because one of the researchers has been pursuing certification as an EM practitioner and is a current officer within said caucus.[1]

The final instrument included 38 Likert-response questions with 3 additional open-ended questions at the end. The survey used *skip patterning* – whether or not some questions were asked depended upon responses to other questions (e.g., "Are you or were you ever in the armed forces?" or "Does your agency or unit use social media."). By providing skip patterning, respondents were asked an average of 30 questions, with respondents in the armed forces who use technology in their office being asked up to 38.

On average, respondents took around 15 minutes to complete the surveyt. The sample of respondents were discovered through a combination of our online presence as emerging practitioner academics via social media (Facebook and Twitter), snowball sampling, and social capital related to one of the researcher's Advanced Academy course and membership in the IAEM's ETC. After controlling for completed surveys and all questions present, 126 personnel in some form of EM completed the survey. The structure of the survey is as follows.

3.1. Survey Structure

The validated CSed instrument was chosen for 3 reasons. First, CSed as a field is quickly establishing best practices with regard to teaching computational concepts [61, 62]. Second, this instrument is used to evaluate where students are when they begin an introductory computer science, human-computer interaction, or technology-based course. Finally, this instrument focuses on what the ETC at IAEM was interested in as it measures basic competency with

[1] More information about the ETC can be found at `https://www.iaem.org/groups/us-caucuses/emerging-technology`.

technology and can be adjusted to reflect technological practice as it is now and how it could be simultaneously.

In the survey, respondents are first asked demographic- and context-oriented questions relating to who they are, their gender identity and ethnic categories, their education, and if they were ever in the armed forces. After these initial questions, respondents answer questions about their relationship with EM. From public health to emergency medical services, respondents were asked to identify their domain, their daily responsibilities, their level of authority, their tenure in EM, whether or not they activate during response, if they are directly responsible for coordinating during disaster, if and how they host software made for EOCs (e.g., WebEOC, ArcGIS, DisasterLAN), whether or not their agency was on social media, and, finally, how or if their agency stored large amounts of data.

After this, respondents work through seven categories: browser and ICTs , social media policies and administration, mapping technologies, cybersecurity, database platforms, programming, and new kinds of hardware (e.g., drones, internet of things).

The scale was adopted from the CSed instrument. The categories are:

- "I don't know what this is,"
- "I am not sure how to do this task,"
- "I have done this but might need some help,"
- "I can perform this task without any assistance,"
- "I could train staff to do this."

This scale allows researchers and developers to quickly reference how their products might be received.

4. Analysis

This is a report on a survey created and administered to EM practitioners across all levels. In total, there were 126 valid competions ($N = 126$). Of those valid respondents, 75% fell between age 25 and 55. 1.6% reported being under 25 whereas 25% were older than 55. 97% of respondents noted that they did not identify as Hispanic with 3% identifying as Cuban, Mexican or Puerto Rican. 88% of all respondents identified as white / Caucasian with Black / African American being the next highest ethnicity at 3%.

These data fall in line with previous evaluations of EM [63, 64]. We can say without controversy that *EM is not a diverse domain*; this lack of diversity has additional consequences [59] that will be discussed later. This section moves through the technologies surveyed: browser and internet communication technologies, social media policies and administration, mapping technologies, cyber-security, database platforms, programming, and finally new kinds of hardware.

4.1. Browser and Internet Communication Technologies

Browser and ICT have become a ubiquitous aspect of everyday technology use. This section shows that while EM is generally light in terms of technology usage, ICTs are well-integrated within the everyday life of EM practitioners. The items asked about are: setting up a private browser tab, setting up email accounts, using formulas in programs like Excel, tethering one's mobile device as an access point for laptops or other computers, virtual private networks, and optimizing computer security settings.

Overall, more than 80% of respondents could open a private browser tab and set up email accounts. After this, a little over 60% of respondents could use formulas in excel without assistance or could train staff to use them. In terms of network access, 70% of the men who responded and 60% of women felt that they could use their mobile devices as a tether as well as to set up a VPN. Only internet security saw a much wider distribution with 50% of men and 60% of women saying they were either not sure how to perform that task or are unable to do it at all. As with all technology use, there is an expectation about age and that if one is younger that one will be better with technology [65]. And yet, the results of the survey indicate that age is not a factor in any way–this will be addressed in the discussion.

These technologies generally represent the present state-of-the-art in EM. It is these technologies that the "IT office" of any EOC will maintain. ICS / NIMS are where this responsibility originates. While we show here that those technologies that are currently used exist well within these frameworks, the rest of the survey pushes back on this notion of the IT office through the weaknesses outlined by the OIG [5] as well as the ETC's guidance.

4.2. Social Media Administration and Policy

Social media (SM) use, admin, and policy is of particular interest to the EM and CI researchers [66, 67]. The questions for this section focus on setting up a Facebook page, a Twitter account, and a TikTok account; communicating with the public via social media; and writing both social media use policy and public engagement and data sharing policy. These questions were informed by the ETC as well as by CI through [67]. 60–70% generally understood how to set up accounts and communicate with the public. Yet, 50% of respondents had no idea what the short-form video sharing platform called TikTok was.

60% indicated that they did not know how to, "write policy for engaging online emergent groups" or would need help. While this leaves 40% of respondents indicating that they could write policy, 50% of respondents who are spread out across local and state jurisdictions state that they do not know how to create policy or what that policy might be. Overall, this collection of responses provides immeasurable worth to CI researchers seeking to develop tech for EM.

4.3. Mapping Technologies and Geographic Information Systems

For EM practitioners, the map is one of the most common objects for coordination, situation awareness, and the foundation of practice itself [68–73]. Given the previous discussion of social media policy and the additional queries about browsers and internet communication technologies, this section was again poking not at practice generally, but at sharing and maintaining data, especially in geographic information systems (GIS).

Surprisingly, or perhaps not given the specialty of geo-spatial analysis, the most common task that respondents had confidence with was printing a map from GIS specifically. When asked if they understood how to maintain layers, analysis data from GIS, or share those data with others, most respondents (70% or more) indicated that they would need help to perform the task at best. Through the incident command system (ICS) or the hierarchy all response efforts use, it is important to note that even if this technology is part of their duties, they do not fully understand that product.

4.4. Cyber-security

Recent issues with ransomware, malware, misinformation, and cyber-security point to these next questions which focus on protection and response to cyber-attacks. The items queried were making exceptions to firewalls, using 2-factor authentication, encrypting hard drives, responding to malware, responding to ransomware, and identifying cyber-vulnerabilities. Given the growing presence of cyber-related vulnerabilities, this group of questions is perhaps the most important of the survey. Expectations for this section from ETC are best collected in one of the best quotes from working with the ETC, "There is not a technology gap in EM, it is the Marianas Trench." As such, we expected the data from this point on to be dominated by "I don't know what that is" and "I am not sure how to do this task."

First, firewall exceptions scored the highest in this block in terms of the response, "I don't know what that is" at 60%. In fact, the questions in this section begin a trend toward, "I don't know what that is" as more and more specialized technology is discussed. Only 20% of respondents felt comfortable stating that they could make firewall exceptions without any help or could train those respondents. Each age category, spread out over 10-year blocks beginning with age 19, is similarly represented though the age category of 55–64 did represented 1/3 of the 64 respondents who indicated they did not know how to perform firewall exceptions.

4.5. Knowledge of Databases and Their Applications

The questions from the previous block concerned the various aspects of the social life of computers and the ways that computer use can be a vulnerability in and of itself. In this block of questions, the target moves from the socially-oriented knowledge, to more technical concepts involving data itself. In specific, this block of questions could be referred to as, "the data science block" in that it involves the creation of datasets and methods of analysis. Here, respondents were asked about: querying unstructured and structured data, deploying Amazon Web Services (AWS) to maintain a network connectivity, adding information to a database, using advanced search functions or Boolean functions, and finally, two items about the growing threat of vulnerabilities related to misinformation.

Throughout the COVID pandemic, there have been a variety of discussions about data storage and the impact of a lack of consistently available data for public health and EM to analyze. As personnel who are responsible for setting up testing sites, vaccination sites, and tracing protocols, knowledge of database platforms is paramount to future local, state, federal, and international crises, disasters, and coordination. Due to this increased importance of data and data storage, it is disappointing to see that only 20% of men and 13% of women respondents could perform queries on unstructured data which is data gathered without an existing data model. This is in agreement with the 29% of men and 58% of women performing data on structured data which is gathered with a model in mind.

When coordinating access to data in large-scale events, bandwidth issues often present a hindrance to that coordination. EOC-oriented bandwidth needs is often in need of flexibility and scaling. Thus, the inclusion of a reference to AWS, which allows one to scale web access based on need. 73% of respondents who identify as men and 95% of respondents who identified as women did not know what AWS is or how to deploy it. Some may respond to information like this and say this is not relevant to EM practice but the IT office. Yet, we point back to [5] and note that the IT office has had little impact on any aspect of EM and so, we seek to understand current tech knowledge in an effort to push back on ICS and NIMS in an effort to correct that lack of impact.

Finally, the instrument asked about adding data to a database, Boolean operators (AND, OR, IF), and misinformation. Of these, more than 80% noted that they had either done this task or could train others on it. While positive, the questions themselves may have different kinds of interpretation. For example, adding data may be interpreted through *Excel*, identifying misinformation could simply mean identifying incorrect information, and fake accounts may be interpreted as overt fake accounts versus stolen accounts broadcasting fake information. More research is needed.

4.6. Basic Programming Knowledge

One of the tenets of computer-based knowledge is how computer code is related to what is seen on the screen. This is additionally important to CI-oriented tools as the complex dependencies and components of machine learning and artificial intelligence requires far more in-depth knowledge than most consumers will possess. Much of what the respondents answered to this question is situated with existing preconceptions of EM as a technologically deficient space.

At current, technology is not used by EM for incidents like hurricanes, earthquakes, and floods. However, consumer reliance on computation in the form of mobile devices with communication apps is expected, necessary, and a has much potential to increase the survivability of those impacted by these incidents. This block of questions contains the highest, “I don’t know what that is” or “I am not sure how to do this task” with 70–90% of all respondents claiming one or the other. Only 3–10% of all respondents indicated that they could either perform the task without help or train others.

The lowest values of this block hinge on CSV files This is indicative of the earlier discussion of formula use in excel files or other spreadsheets. One aspect of these data that is useful is JSON data. While 45% of women and 36% of men indicate that they do not know what a JSON file is, there is enough who are not sure that simply offering training on the use of JSON data could open up myriad potential avenues of technology integration.

The difference between the responses to “interpreted” versus “compiled” languages indicate additional potential avenues for technology integration and CI work to find allies. While there is much work to be done about programming skills, languages like Python and Lua which are interpreted languages have at least a little more representation inside of EM than that of compiled languages. This is an important discovery as Python especially may be slightly more known and therefore a vehicle through which training can be pursued. It is additionally useful to see that accessing Application Programming Interfaces (APIs) is slightly more well-represented than the computer languages themselves. As a result, pulling data via APIs could additionally be a useful method of training.

4.7. Drones, Networking Hardware, and Internet of Things

Finally, respondents answered questions related to flying drones, setting up routers, setting up mesh networks, using HAM radio, setting up Internet of Things (IoT), and setting up networked printers. These questions are related to both old and new technologies but also practical and needed tools for bases of operation, EOCs, and various kinds of mobile command. Despite these needs, many respondents noted that they were not sure how to fly drones with just 29% stating that this was something that they knew how to do without assistance or could train others to do.

Regarding routers and mesh networks, IoT, and printers, these are necessary items for any a BOO and while many may relate these to the “IT division’s” duties, the overlap of skills and domain were called upon when answering questions earlier in the survey related to everyday job skills. As a result, these may be ICT-oriented items that get relegated to the technology officers. However, the overlap of skills relating to administration, performance, and non-tech-oriented tasks seems to stand in stark difference to that of tech-oriented ones. This needs to be unpacked.

5. Discussion

In this section, we provide possible first steps in solving the tech crisis in EM. First, we will discuss the implications of, “I don’t know what I don’t know.” Next, we touch on something that was at the background of much of the data analysis – age. And we end with a discussion of potential steps to address the crisis.

5.1. The Red Slice: I Don’t Know What I Don’t Know

One aspect of EM that confounds inquiry is that it is a field of specialists. Because EM is still becoming a discipline, this specialization is a natural extension to those domains that currently funnel into EM. In addition, the ICS framework [15] is rigidly followed and, while certain aspects of practice are flexible in the midst of a response, the hierarchy and responsibilities are not. Consequently, choices of how teams operate is a function of the specialists available and how they are deployed. Specialists know what they know, they may know some of what they don't, but the big concern is what EM refers to as the "red slice" [74]: not knowing what you don't know.

These "red slice" issues are made worse by new tools meant to provide better coverage, tracking abilities, and messaging to people about to be impacted by a disaster event. The most recent example is the 2020 west coast wildfires, wherein software would not work due to a programmer's error on a live product meant to be able to broadcast alerts [56]. Other software for alerting used out-of-date maps resulted in evacuation alerts for areas where no evacuation was necessary [56].

Mobile technologies were also responsible for missed phone calls due to quiet mode that EM did not know how to override [57]. Each of these issues point to a need to provide training to personnel, but also that EM needs to step up their outreach to ask for things they do not know they can. However, in order to do this, there needs to be allies from within EM, ones that are traditionally from younger cohorts or generations yet this seems to be nonexistent in EM more generally.

5.2. Age and Technology in EM

One of the striking things about these data is that age fostered little diversity of viewpoint. There are perhaps 2 different interpretations of this result. First, sampling issues may have simply aligned to negate the possibility of a significant age effect. However, much of this is negated as one of the researchers has been working as a practitioner for the past few years and has yet to find *any* computer scientists.

Additionally, there is little age consistency in training despite consistent expectations and requirements of performance. Next, EM does not require technology and so, does not attracting tech workers. However, what is more likely is that EM removes tech skills even from tech-focused workers with comments in the data like, "Most of the IT-related skills I have are not needed in an EM..." This comment is reified by another practitioner who noted, "the tasks in the last section [programming, IoT] are handled by dedicated IT techs." Perhaps the most important aspect of these quotes is it reifies the OIG [5] report that the "IT person" in EM is a failed construct.

5.3. Potential First Steps to Solving the Technology Crisis in EM

The results of this survey from a development and technology space is somewhat stark. There is little to no technology use within EM and little to no exploration asked for, expected, or as part of training. CI, in general then, is confronted with a space that is not only unwilling to engage, but even if they were, are not trained to deal with complex dependencies, tools, and the various components of computer science that cannot be reduced in complexity.

That said, while stark and reinforced by training and employment pipelines, there are some threads that could be pulled on, some spaces that can be pushed on to begin to open up potential areas of development. The first of these are data formats. EM is a space marked by spreadsheets and CSV files. Opening EM to new types of data formats can create opportunity for new tech.

5.3.1. JSON & Other the Potential of Data Formats

In becoming practitioners, we understand that the spreadsheet is a nearly ubiquitous piece of ICT in EM. Rows and columns provide a large amount of potential for data analysis, data science, and data analytics, but, within EM, the components of any response are complex, multi-dimensional, and could be better served to better help prepare responders to actually respond.

Within the survey results, we see that there is an average of around 40% of respondents who do not know what JSON is. While 40% is a significant amount, an average of 50% are simply not sure how to analyze data in a JSON file. A significant step in opening the door to new kinds of technology will be in new kinds of data formats. JSON provides that new kind of data, is able to be opened in *Microsoft Excel*, and provides useful mental models that call upon things like dictionaries. While perhaps not a panacea in and of itself, the number of people who have at least heard of JSON as a file format hint at it being a useful foundation to build on.

6. Conclusion

The most pressing next step is to identify what aspects of technology can help move EM past its current level of tech integration. Perhaps the most important philosophical aspect of these next steps is to avoid technological determinism or the presumption that tech can *save* EM. Simply providing equipment to EM organizations is not possible as the knowledge of those tools is non-existent and not possible to learn within current EM structures. The lack of ICT use in EM is creating issues that worsen with time and simply throwing more tech at EM will exacerbate the situation.

The most pressing concerns for tech in EM is that EM is often at odds with human-centered computing and computing in general. Software for EM needs to work without fail. Hardware for EM needs to withstand the extreme conditions that EM personnel sometimes engage in. Local residents who form communities with people online during a response effort need to be able to coordinate with EM personnel. All of these realities, from those tasked with stabilizing response efforts, those on the ground responding to disasters, and those being responded to, need to be contextualized to begin to understand what sorts of solutions can be sought.

While EM personnel may have a variety of administrative tasks and levels of responsibility, IT tasks are forwarded to others who shoulder much of the technological needs of EM but do so without power. Future work generated by this survey will focus more directly on what the future of EM practice should look like. Through a simple data format training, additional software, programming languages, and tools can begin to be introduced within the training modules that EM currently deploys. Overlapping skills and responsibilities set to a technological standard will foster a more cohesive set of emergent practices during crisis, one that could harness the vast potential of the crowd. Further, different types of data structures may provide useful ways for new types of training to show new and well-seasoned EM personnel potentials they had not previously known.

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