Perceived Exposures of Disaster Scientists and Experts that Participated in Ridgecrest Earthquake Reconnaissance

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Abstract

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This study explored the perceived occupational exposures and health impacts of disaster scientists and experts that performed reconnaissance in Ridgecrest, CA following the magnitude 6.4 and 7.1 earthquakes that occurred on July 4 and 5, 2019. We conducted and thematically analyzed semi-structured key informant interviews with 18 individuals that performed reconnaissance. Interviews explored occupational exposures, risks, and health impacts, as well as how participants proposed to mitigate these exposures and improve their occupational health and safety. Common physical and safety hazards encountered included heat, brush, and falling-object hazards. Psychosocial hazards included interactions with affected communities and long work hours. Other factors reported to influence occupational safety and health included fatigue, interactions with local officials, access to resources (e.g. food, water, and fuel), team dynamics, and training. Lack of uniform training requirements for reconnaissance activities resulted in various levels of training among study participants. Participants had various levels of experience ranging from none to over 30 years. This study provides an unprecedented look at occupational health issues faced by disaster scientists during disaster reconnaissance. We identify several opportunities to improve the health and safety of disaster scientists during future reconnaissance trips, as well as additional research needs.

Introduction

Overview

A disaster is an event that creates a critical disruption to society, resulting in the affected society's dependence on external resources to respond [1]. The United States experienced 12.6 extreme weather events per year between 2013-2018, double the original projection of 6.3 by the U.S. National Oceanic and Atmospheric Administration's (NOAA) National Centers for Environmental Information (NCEI)[2]. Disasters are expected to increase in frequency, magnitude, and intensity due to the effects of climate change and urbanization [1,2]. As this trend continues, disaster workers and responders will face emerging risks during their work. It is essential to understand these risks to protect their health and safety.

Given the frequency and impact of disasters, scientists from a variety of disciplines have become increasingly interested in understanding their impacts and the effectiveness of disaster response and recovery strategies. Following disasters, individual scientists and teams of scientists will rapidly deploy to disaster-affected locations to collect perishable data. Perishable data, such as information on damaged infrastructure, must be collected in real-time as it may no longer be available following disaster response or recovery [3]. The process of collecting perishable data is known as disaster reconnaissance [3].

Individuals and teams deployed to conduct disaster reconnaissance must work critically and safely to reach their professional and organizational goals. The teams must arrive within the first few days or weeks following a disaster, a crucial response period. While being mindful of their vulnerabilities and hazardous work environment, they must work efficiently to gain an accurate understanding of the disaster's impact through their observations and data collection.

However, there is limited information on the health and safety risks, protective actions, and their consequences for individuals conducting disaster reconnaissance throughout the deployment process to disaster-affected areas. However, recent literature reviews summarize the mental and physical impacts among disaster workers which may potentially be applicable to these individuals.

Literature Review

While limited research exists about the health and safety impacts to individuals conducting disaster reconnaissance, research on other disaster response and recovery workers point to the potential myriad exposures that lead to short- and long-term health consequences. For example, results of a self-report questionnaire from Wisnivesky et al. revealed the first physical symptoms reported among emergency responders at Ground Zero (9/11) were respiratory irritations[4]. Further evaluation found that emergency responders experienced a host of occupational exposures including physical exposures, chemical exposures, biological exposures, and psychosocial exposures[5]. Incidence of physical and mental health disorders increased as the years progressed, and participants with previous history of these disorders were more affected. Approximately 30% of workers still had medical disorders after the nine-year period of the study[4].

A cross-sectional study of 2,384 Coast Guard members evaluated the mental and physical health effects and exposures from Hurricane Katrina and Rita. The study categorized respondent activities at the sites by intensity; high-intensity efforts included search and rescue, building cleanup, and body recovery [6]. The

results of the study found the 54% of participants in high-intensity missions were more likely to be young and wear PPE. These same responders were also less likely to experience depression, sinus infections, and difficulty focusing during missions [6]. The most common exposures reported by the members were insect bites (mosquito bites), animal scratches and flood waters (e.g. exposure via submersion, ingestion, or inhalation) [6].

Additionally, research on disaster recovery workers raises concerns about the use of PPE and potential for compounding health impacts. Erickson et al. conducted a study to evaluate the association between the use of personal protective equipment (PPE) and heat-related symptoms among 3,948 surveyed U.S. Coast Guard members involved in the clean-up of the Deepwater Horizon oil spill [7]. A majority (67%) of the surveyed workers reported working at least one day in 100°F temperature or greater with PPE (long-sleeve Tyvek suits, gloves, and face masks). Eighty percent of those working in these conditions reported experiencing heat-related symptoms, even though only 1% sought medical treatment for them [7]. These findings indicate the large potential for PPE use among disaster workers in high heat environments to result in various degrees of heat-related illness.

Mental health impacts are also of potential concern, especially when disaster personnel are working near survivors. For instance, a review of data from a self-reporting survey of 1,506 Defense Force members who responded to the Great East Japan Earthquake found indirect traumatic exposures to victims (living within the response area) affected responders more than direct exposures (e.g. the responder's personal experience with the disaster)[8]. Dobashi et al. also reviewed the psychological effects of the 606 Defense Force members who responded to a self-report questionnaire to assess symptoms of psychological distress and PTSD a month after their mission to an affected area[9]. Results suggested members may have experienced other trauma prior to taking the survey, and their responses may have reflected trauma related to other events and not exclusively related to the earthquake[9].

The literature on occupational health impacts among disaster responders and recovery workers can also inform interventions to minimize exposures and health impacts for individuals performing reconnaissance. For example, a study by Mattei et al. explored the need for interventions to reduce workload and stressors, along with improving adaptive coping strategies, especially in post-disaster settings following the L'Aquila earthquake[10]. The study surveyed 535 healthcare workers (doctors, nurses, and healthcare assistants) for symptoms of burnout one to three years following the earthquake. It found one quarter of workers expressed having grief and experiencing stress or distress following response efforts. Recommended interventions involved educating healthcare workers on stress and adaptive measures. Mattei et al. also recommended encouraging healthcare administrators to be more aware of the concepts and symptoms of burnout among their employees[10]. This study could help disaster workers and organizations understand how factors of their work can contribute to burnout and ways to mitigate those factors.

With a multitude of potential physical and mental hazards and impacts, training may aid in alleviating and mitigating their effects. Errett et al. evaluated associations of workers' self-efficacy and training in a study of health department employees affected by Hurricane Sandy. The study found approximately 74% of participants hired prior to Hurricane Sandy understood and were confident in their ability to perform their disaster recovery role[11]. Analysis also found that participants with prior disaster training were more likely to have confidence in their roles during a disaster compared to those who did not. Four

hundred ninety nine (80.35%; 499/621) participants indicated they would likely be asked to participate in future disasters and 90% indicated they were willing to participate, if asked[11]. Willingness to participate was strongly associated with prior training, safety at work, psychological support, and liability protection[11]. This study further emphasizes the opportunity for training to enhance disaster scientists' confidence in disaster situations.

Despite these parallels, to the best of our knowledge, few programs exist to prepare individuals conducting disaster reconnaissance for health and safety hazards they may experience in the field. The National Institute of Environmental Health Sciences (NIEHS) Worker Training Program (WTP) Deployment Guide and Earthquake Engineering Research Institute's (EERI) Health and Safety curriculum are among the few available resources to prepare individuals conducting reconnaissance safely.

The NIEHS WTP provides classroom training, online courses, and booklets that advise individuals conducting reconnaissance to stay connected with their deployment group, not overwork themselves, and avoid negative coping strategies. The deployment phase of the program emphasizes that workers should follow the Incident Command System, have adequate communication, and follow their role assignments. Following their deployment, the deployment guide encourages workers to seek medical and psychological treatment [12].

Additionally, the Earthquake Engineering Research Institute (EERI) provides a health and safety curriculum through its Earthquake Reconnaissance Field Safety (ERFS) training. The training aims to teach members to evaluate the risk they are presented with in the field [13]. It provides a list of common hazards associated with earthquake affected areas including poor infrastructure, hazardous materials, dust, and fatigue [13]. The safety training also encourages members to bring their own supplies of perishable food, water, and safety equipment so that they do not take resources from the affected community [13].

The training stresses that researchers should not try to collect data where active response efforts are occurring, so they do not put responders, survivors, or themselves at increased risk of injury. Furthermore, the use of protective equipment, staying with team members, having proper identification, and being knowledgeable of surroundings is advised [13]. The EERI's program also places the responsibility of the team's safety and health with the members.

Next steps

There remains limited evidence about, and thus evidence-informed interventions to reduce, the occupational exposures or health and safety impacts of individuals performing disaster reconnaissance. Using the 2019 Ridgecrest Earthquake as a case study, this thesis uses semi-structured interviews with individuals that performed reconnaissance to understand perceptions about their occupational exposures, mental and physical health impacts, and implementation of mitigation strategies. We propose recommendations to enhance the health and safety of this growing disaster workforce.

Introduction

In order to understand disaster impacts and improve overall resilience, interdisciplinary groups of professionals will travel to disaster-affected locations to make observations and collect **perishable data**, defined as information that must be collected and analyzed in real-time and will no longer be available following the clean-up of a disaster [3].

This activity, known as **disaster reconnaissance,** generally occurs within the first few days or weeks following the disaster. As this is a crucial response period, those conducting reconnaissance must be careful not to impede the work of first responders or take essential resources from affected communities. While being mindful of their vulnerabilities and the hazardous environment they are in, they seek to understand the impact of the disaster through observation and data collection.

Despite prior and ongoing work assessing risks to disaster responders and recovery workers, health and safety risks to individuals conducting disaster reconnaissance have been understudied. While they are not traditional members of the disaster response workforce, these individuals or reconnaissance teams may face similar stressors when operating in disaster-impacted locations compared to other disaster workers. Individuals conducting reconnaissance receive varying levels of training which are not required nor as rigorous as professional first responders [14]. This comparison raises cause for concern as reviewed literature showed volunteers were more susceptible to the adverse effects from both psychological and physical health impacts during and after response efforts[15,16].

Disaster-related occupational health risks

Disaster responders and recovery workers face a variety of occupational health risks. Several literature reviews have summarized the available evidence about these risks, as well as interventions to minimize them. For example, Khatri et al. conducted a literature review exploring the physical and mental health risks and injuries associated with hazards related to geography and extreme-climatic conditions experienced by disaster relief workers and volunteers [17]. Reviewed literature identified physical and mental injuries and illnesses experienced in the immediate (e.g., cuts, wounds, fear, stress), short- (e.g. burnout, infectious disease, anxiety), and long- term (high blood pressure, diabetes, Post Traumatic Stress Disorder) [6]. The review found the combination of job strains, injuries, and adjusting to new responsibilities resulted in more severe mental and physical injuries or illnesses [17].

The literature review resulted in the development of a conceptual framework which describes the relationship between the nature of these physical and mental injuries, influencing factors, and mitigation strategies (Figure 1). Identified influencing factors included types of events, types of responders, socio-economic standing, and living/working environment. Mitigation approaches are methods used to reduce worker's vulnerabilities to mental and physical injuries. Identified approaches included pre- (e.g., protective equipment, vaccination, training, recruitment criteria) and post- disaster (e.g., safety equipment, organizational culture, post-disaster health monitoring) approaches.

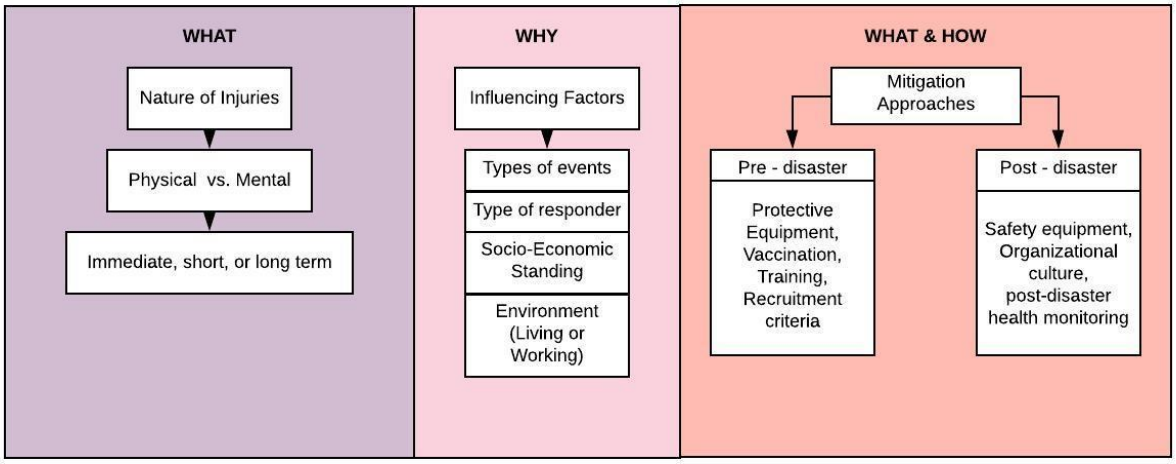


Figure 1: Conceptual Framework adapted from Khatri et. al[17]

While Khatri et al. provided an overview of physical and mental injuries, Brooks et al. conducted a literature review to identify risk and resilience factors of humanitarian relief workers that can predict psychological outcomes [18]. The study intended to provide recommendations for reducing risk and encourage resilience in humanitarian relief workers [18]. The included sixty-one qualitative and quantitative studies focused on factors determining any psychological outcomes in humanitarian aid workers.

The reviewed literature identified 11 themes that psychologically affected workers during pre-, peri-, and post- disaster relief work. The review identified preparedness training as a pre-deployment theme, peri-deployment themes included deployment length and exposure, and post-deployment themes were media coverage and professional growth. The review revealed that many workers believe individual post-deployment debriefings should be mandatory versus being requested due to traumatic exposures [19].

Conversely, Rose et al. conducted a review on individual and group debriefings and found that debriefings could have adverse side effects for those who have experienced traumatic events. The study conducted a review of 15 randomized and quasi randomized trials and found there were no significant differences between the intervention (individual and group debriefings) and control groups within 3-13 months following the event. The study was able to conclude that there was no supporting evidence that debriefings reduce the risk of developing adverse mental health effects following traumatic exposures, and that participants with the highest risks would not be benefitted by a single session and may experience more adverse effects from participating in debriefing sessions [20]. Rose et al.'s study provides insight for employers who may be considering debriefings following their deployments.

Quevillon et al. provided an overview of best practices to help disaster relief workers experiencing physical and psychological harm throughout disaster relief operations. The article discussed cases with evidence supporting organizational commitment, policy, procedures, leadership, team building, management, and supervision. Organizational models with these features build resilience in disaster workers. Quevillon et al. explored strategies for post-traumatic growth, along with self-care, before,

during, and after the disaster [21]. The article further emphasized the importance of preparedness for workers to aid in mitigating challenges and reducing distress.

Next steps

In order to build the evidence base about occupational health and safety risks, protective actions, and consequences specific to individuals conducting reconnaissance, we conducted a case study of individuals that deployed in the immediate aftermath of the 2019 Ridgecrest Earthquakes in California.

Ridgecrest Earthquake

On the evening of July 4th a M 6.4 earthquake followed by a M 7.1 earthquake on July 5th occurred in the Ridgecrest, with numerous M 4.7 aftershocks after the event [22]. Local Ridgecrest fire, police, and EMS departments responded to affected areas [23].

The USGS reported no fatalities but did estimate there was approximately $10 million - $100 million in damages following the earthquakes. The Southern California Earthquake Center reported house fires, several collapsed mobile homes, and collapsed chimneys following the earthquakes [24]. Both events were strongly felt in the China Lake-Ridgecrest area and broadly felt from Los Angeles, CA to Las Vegas, Nevada [22,25].

Several Disaster Research Reconnaissance (DRR) groups, including the Earthquake Engineering Research Institute (EERI) and Geotechnical Extreme Event Reconnaissance (GEER) team, deployed to the affected area to capture information about affected infrastructure and residents [26]. The EERI set up an information clearinghouse at a local hotel in Ridgecrest, California for individuals and teams conducting reconnaissance from various organizations to come and discuss their findings every evening. There were approximately 51 people present at the clearinghouse, but it is possible the numbers fluctuated overtime as individuals were arriving and leaving as their research required and may not have signed the log form for the clearinghouse meetings.

Research Aims

This study seeks to explore the occupational exposures and outcomes of individuals performing disaster reconnaissance and address the following aims:

Aim 1: Identify and describe perceived occupational health hazards and outcomes faced by individuals performing disaster reconnaissance following the 2019 Ridgecrest earthquakes.

1. What are the physical, psychosocial, and safety hazards experienced by disaster reconnaissance researchers following the 2019 Ridgecrest earthquakes?
2. What are the physical and mental health impacts experienced by disaster reconnaissance researchers following the 2019 Ridgecrest earthquakes?
3. What are the influencing factors behind health outcomes experienced by disaster reconnaissance researchers following the 2019 Ridgecrest earthquakes?

Aim 2: Explain opportunities to mitigate the health and safety impacts on individuals performing disaster reconnaissance through workplace control measures.

1. What workplace controls have 2019 Ridgecrest earthquake disaster reconnaissance researchers used and how do they perceive their impacts?
2. What factors influence the disaster reconnaissance researchers' willingness to use workplace controls?

Methods

Conceptual Framework

The conceptual framework for this study integrates components of disaster preparedness and influencing factors related to acquired injuries from Khatri et al.'s conceptual framework for disaster responders and aspects of self-efficacy and decision-making from Lindell and Perry's Protective Action Decision model[17,27].

The framework (Figure 2) proposes that the perceived exposures faced by individuals conducting DRR directly influences engagement in disaster mitigation strategies, perceptions (stakeholder, protective actions, and threat) and the nature of injuries. These factors also interact within and among themselves while also being shaped by underlying influencing factors (e.g., type of disaster, type of responder, length of membership).

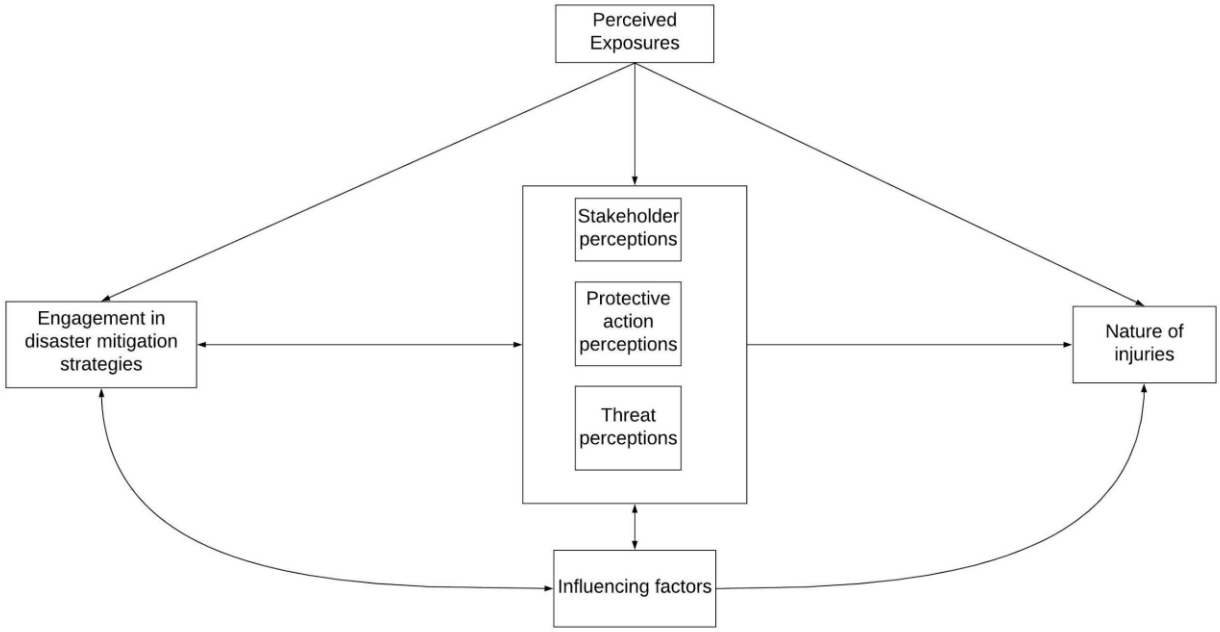


Figure 2: Conceptual Framework, adapted from Khatri et al and Lindell & Perry[17,27]

Both aims seek to explore how the views of disaster researchers are influenced by training or personal perceptions regarding threat, protective actions, or stakeholders. Disaster researchers participating in 2019 Ridgecrest earthquake reconnaissance may have differing views on what they believe to be threatening and the protective actions they engage in. The stakeholder perceptions are those influenced by professional and academic organizational goals for their reconnaissance mission. In turn, these

perceptions can have effects on the nature of injuries and other health and safety consequences experienced by disaster researchers during reconnaissance.

Study design

We conducted semi- structured interviews with a purposive sample of key informants. These key informants, herein referred to as participants, were selected based on their participation in reconnaissance activities associated with the EERI California Clearinghouse following the 2019 Ridgecrest Earthquakes. EERI provided names and contact information for all researchers who participated in in-person clearinghouse activities (n=51). EERI sent an email to all participants notifying them that members of the study team would be contacting them to participate in the study. We then followed up with individual emails to all participants explaining the study and inviting them to participate (Appendix A). We continued recruitment until saturation, or the point in which no new themes are identified through additional data collection [28], was reached.

All interviews lasted between 30 to 90 minutes and were conducted by phone between January 13, 2020 - February 18, 2020. Participants were provided with a verbal description of the study and informed consent statement. Participants provided verbal consent prior to their participation.

The interviews were guided by a semi- structured guide developed in advance based on the study's aims and conceptual model (Figure 2). The interview guide (Appendix B) was reviewed by three researchers experienced conducting disaster reconnaissance, but who did not participate in Ridgecrest reconnaissance activities, to ensure question clarity and appropriateness. Questions were provided to the interviewee prior to the interview to aid in their preparation.

All interviews were conducted by one member of the study team (BW), apart from the first interview. During this first interview, a senior member of the study team (NAE) joined the interview to provide feedback on the interviewer's technique and identify potential corrections to the interview guide. Interviews were recorded with participants' permission and field notes were taken. Recorded interviews were professionally transcribed.

Once transcribed, we provided participants a summarized version of their transcribed interview to review to ensure key points were appropriately interpreted. Simultaneous with this validity enhancing process, known as member checking, we created an "interview contact sheet" for each participant which contained de-identified information such as an interview number, a summary of the key themes identified through their interview, member checking status, and any edits to interview summaries following member checking[29].

We used deductive and inductive approaches to data analysis. First, a deductive codebook was developed based on the literature review, study aims and conceptual models. Following the interviews and data familiarization (i.e., listening to interview recordings, reading interview transcriptions, and developing interview summary sheets), we added inductive codes representing themes that emerged through the interview process.

Once transcribed, the interviews were coded in NVivo software. Two de-identified transcripts were co-coded with a researcher external to the study team. Coded text was compared, and discrepancies were adjudicated via consensus building discussion. In instances where code discrepancies were due to misinterpretation of codes, the codebook (Appendix C) was refined to clarify code descriptions or instructions. Following co-coding, a single member of the research team (BW) proceeded to code the remainder of the interviews. Following coding, coded text aligned with constructs associated with each research question was read and re-read. Text was summarized and synthesized in analysis memos specific to each research question. Analysis memos were then cross-referenced with interview summaries to ensure they were reflective of key points, as confirmed through member checking processes.

Visualizations were then created to see how the codes interacted and related to one another. A cluster (Appendix D) diagram was created in NVivo to better visualize how the codes were relating to each other in terms of word similarity. Another visualization in NVivo was a hierarchy density chart (Appendix E) which displays the amount codes were used throughout all the interviews with more frequent codes having wider squares than others. A concept map was also created in the daggity.net program to compare how the codes interacted in the actual data compared with the conceptual model developed *apriori*. These visualizations assisted in understanding how codes interacted and related back to the conceptual model.

This study was determined to be human subjects research that qualifies for exempt status (Category 2) by the University of Washington's Human Subjects Division.

Results

This section will review the results from our participant interviews. Perceived safety and psychosocial hazards, impacts, and influencing factors (Aim 1) are first discussed. Workplace controls, along with associated participants' perceptions, and potential recommendations for improvements to workplace controls are then presented (Aim 2).

Of 51 disaster researchers contacted, a total of 18 (35%) agreed to participate in our study. Participants were predominantly male (77.8%) and were employed by a variety of organization types, including academia, government, and private organizations. The years of experience among participants ranged from 0 to 40 years, with 7 participants having one year or less and 11 having 20 years or more. Table 1 displays the demographics of study participants.

Table 1: Demographics of Participants

Demographics	n (%)
Sex	
Male	14 (77.8 %)
Female	4 (22.82%)
Range of years of experience	0 - 40
<1 year of experience	7
>20 years of experience	11

Organization Type*	
Academia	4 (21.05%)
Private	7 (36.8%)
Government	
Federal	2 (10.5%)
State	4 (21.05%)
Independent	2 (10.5%)

*Some participants identified with more than one organization type, resulting in more organization selections than participants.

Aim 1: The components of the conceptual model boxed (Figure 3) emphasize the sections of the model that were addressed within Aim 1. The aim primarily focuses on identification of perceived occupational exposures, their impacts, and the additional influencing factors. Identified influencing factors included types of events, types of responders, socio-economic standing, and living/working environment[17]. The nature of injuries portion of the model pertains to the immediate, short, and long term physical or mental health injuries and illness[17].

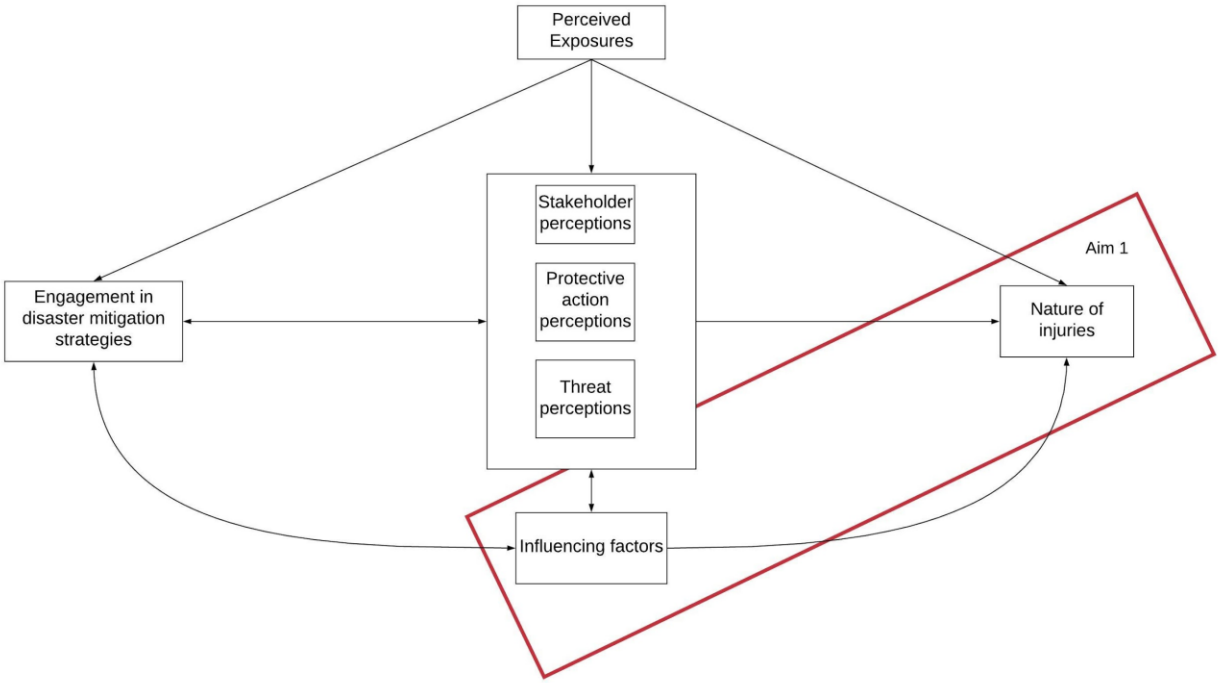


Figure 3: Aim 1 of study highlighted on adapted conceptual model

Perceived Exposures

Participants reported several common physical, safety, and psychosocial hazards following the 2019 Ridgecrest earthquake series. All participants, except for two, reported being in good health and not possessing any pre-existing conditions that may have impeded their work. Heat was described as the primary contributor to any alterations to mental and/or physical health if unmonitored in the field. There were no reports made about physical illness by participants in this study.

Safety hazards: Most participants named falling-object hazards, tripping hazards, and heat as the primary physical hazards in locations reconnaissance was performed in Ridgecrest, China Lake Naval Base, and Trona, CA. A majority of participants who performed data collection that involved walking in or around buildings reported falling-object hazards such as collapsed ceilings in tagged and untagged buildings and bricks from damaged or collapsed chimneys. Participants also reported entering culverts to observe mains, trenches to observe broken water pipes, and unexploded ordinances in remote areas on the naval base. Participants also mentioned the severity of the hazards in some locations was unknown, as access was restricted to areas where active response was not occurring. As such, not all buildings were able to be tagged when some participants were in the area for reconnaissance.

Participants involved in building tagging, an activity where buildings are tagged with colors associated with the level of damage, reported minimal to no debris on the ground from damaged buildings, although collapsed ceilings were common. Participants interacted with danger and risks under the supervision of other team members. Participants who physically entered buildings or had team members enter buildings reported falling-object hazards were primarily inside buildings because of reported or unreported ceiling collapses. There was no mention of live wires or fumes from buildings. Many participants mentioned these hazards were minimal because the tallest building in the area was about two stories and explained low buildings like these are not very prone to physical damage.

All participants reported excessive heat for all the days they performed reconnaissance; regardless of location or duration of their activities, the temperatures were very high (over 100°F) throughout their missions. Those who conducted activities in remote areas were reported to be the most at risk of heat exposure. While a majority of participants did not recall experiencing heat-related illness or injury, they did recall other team members experiencing symptoms if they were unprepared and not hydrating properly. One participant even mentioned an individual's shoe soles melting due to excessive heat in remote locations.

Other hazards participants mentioned experiencing during reconnaissance activities included environmental hazards from animals and brush. Participants involved in reconnaissance in remote areas stated they were warned about snakes and spiders but did not have any interactions with them while there. A few participants reported that they acquired minor injuries (cuts and scrapes) from desert brush while collecting data at the fault location.

Psychosocial hazards: Some participants did interact with survivors of the earthquake series and reported the experiences as "traumatizing," but there was no other mention of any form of mental health impacts related to reconnaissance following this series. A few participants who witnessed affected families not being able to return to their homes because they were unsafe or who were in shelters stated it was a very emotional and potentially traumatizing experience. Some participants mentioned past mental trauma from other earthquakes as a reason for why they were not impacted in this series.

Most participants reported minimal mental health impacts from this mission. No reported mental health impacts were long term and impacts described were limited to the duration of the mission. Most experienced members and some there for the first time reported feeling excited in anticipation of aftershocks. Most experienced participants with more than 1 year of experience mentioned at least one

new member, from their unit or others, expressed anxiousness about aftershocks and/or fear of sleeping in the hotel during or following aftershocks. Many participants reported they were mentally and physically fatigued due to long days of data collection followed by clearing house meetings, data analysis, and reporting to their own organizations. Table 2 provides a broad overview of the discussed safety and psychosocial hazards.

Table 2: Health and safety hazards experienced

Hazard type	**Exposure Examples**
Safety hazards	Heat, environmental hazards, and falling-object hazards
Psychosocial hazards	Interactions with affected community and 12+ workdays

Factors that may influence occupational health and safety during reconnaissance

Factors identified that may influence disaster researchers' health and safety include participation in training, years of experience, interactions with local officials, fatigue, and access to resources (e.g. food, water, and fuel) (Figure 4).

Training: A majority of participants agreed that some form of basic hazard awareness and mitigation training should be given prior to arrival at their first reconnaissance locations. All participants explained that training is currently optional so that "required" training does not deter membership into their reconnaissance organization. However, a few participants reported they would consider having regular training (e.g. every other year) to maintain membership in their organization. One participant countered the need for any form of required training because it could hinder their ability to collect data and the amount they could collect efficiently. A majority of participants explained their training occurs in booklets, classroom learning, and on-the-ground training. Most participants said engagement in disaster training becomes inadequate because they do not get to apply their skills often given the infrequency of disasters in their geographical area. All participants who received training believed it adequately prepared them to identify and mitigate hazards in the field, and it would be beneficial for all who perform reconnaissance to have.

Years of Experience: A majority of participants had been a part of their organization for years and have been on many previous reconnaissance missions. Experienced participants mentioned their experience made them more relaxed in some situations and less relaxed in others. Experienced participants mentioned they purposefully did not wear proper PPE if they were not monitored or after they passed checkpoints that assessed for proper equipment in prior disasters. Some mentioned they did not bring or wear reflective vests or hardhats so they would not attract attention but mentioned there were stores they could buy the equipment from if needed in the area. Experienced participants stated they felt prepared to identify and mitigate hazards they may encounter in the field, while participants who had little to no experience felt uncertain of whether they could identify and mitigate hazards in more severe

circumstances related to M7+ earthquakes. Participants with less than a year of experience stated they felt confident under the guidance of their experienced counterparts. The same participants also stated that Ridgecrest was an opportune location to apply their reconnaissance skills for the first time.

Participants stated that they do not view themselves as primary responders, but more as secondary responders. A few participants reported they are secondary and believed the impacted community was affected more than they are during their reconnaissance. Most participants reported they had several years of experience prior to the earthquake series and only a few participants reported this as their first mission.

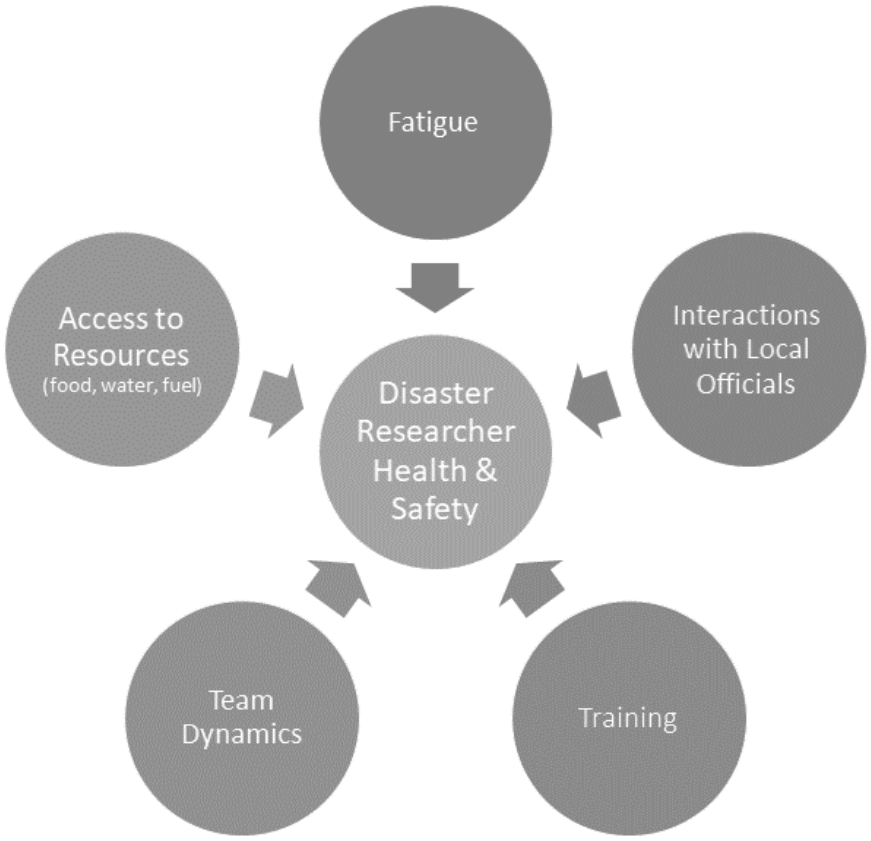
Access to resources: No participants reported difficulty acquiring food or water, and many prepared foods in advance of their trip so they would not have access issues if stores and restaurants were closed. Many participants stated that they were able to fuel up vehicles outside of town before they entered the city. They reported this refueling sufficed for the length of their trip, but they would not have had issues if they needed gas in town unless it was immediately following the M7.1 when services were shut down for safety assessment.

Fatigue: Most of the participants stated they normally pushed themselves to collect data for long time periods. One participant explained it was the "nature of their work" and had to be done to meet their organizational or professional requirements as "papers are seen as a currency" for academic participants. Participants' goals and length of time they were in the area influenced how long their days were. All participants reported roughly 12-15-hour days. Few participants reported only being there for a day while most were in Ridgecrest for approximately 2-3 days and the longest stay being 8 days. Average days included 12+ hours of reconnaissance, followed by meetings and writing reports. Many participants reported an expectation to be fatigued given the nature of their work and reported they perceived the long days as necessary to accomplish their professional goals to progress their field and careers. Participants also reported their data collection was very time sensitive because recovery operations commenced immediately following the M7.1.

Interactions with local officials: Some participants also stated that local officials influenced their work environment and played a role in their health and safety, because they informed participants of locations which were safe to collect data from and those which were not. Participants noted that officials are supposed to have received Safety Assessment Program (SAP) training provided by the California Office of Emergency Services (Cal OES). However, they reported that not all officials had this training, and an untrained official did not require the researchers to perform basic safety procedures (e.g., the buddy system). Participants suggested that state requirements for SAP training were counterproductive; due to these requirements, local officials purposefully chose not to be trained. Participants with trained guides on the naval base stated they were very attentive to their health and safety and took their roles seriously.

Team Dynamics: Many participants also stated pairing of experienced members with inexperienced members helps with teaching new members how to identify and interact with hazards, while newer members have taught more experienced members how to navigate issues (e.g. communication interruptions). Many participants that were geotechnical engineers or in related fields stated they had participated in SAP training.

Figure 4: Influencing factors of disaster researcher health and safety



Aim 2: The second aim of the study focuses on the opportunities to identify and mitigate the identified health and safety impacts through workplace controls. The aim also seeks to understand the levels of compliance with current and future workplace controls. Figure 5 highlights the portions of the conceptual model explored in the second aim. Disaster mitigation strategies can take place before and during deployment to disasters. The perceptions disaster scientists have influenced the situations they operate in and how they interact with them.

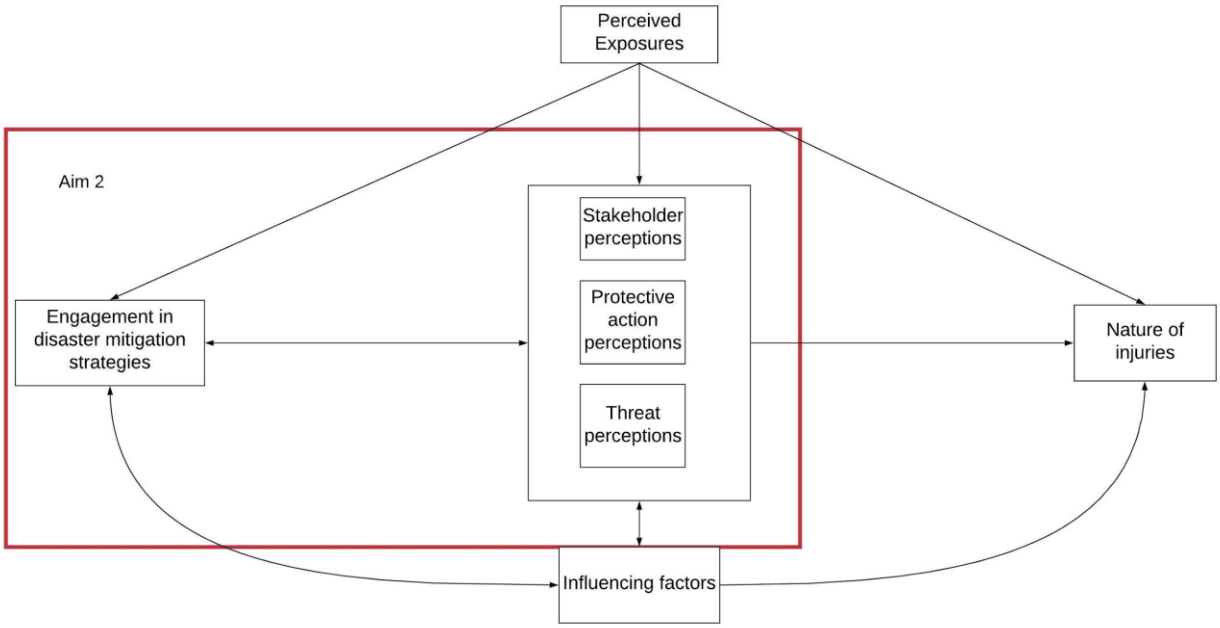


Figure 5: Aim 2 of study from the adapted Conceptual Model

Mitigation strategies

Training: A few participants suggested that simulation training could be used to mitigate loss of latent skills. Participants with experience said training participation can be enhanced by including real and personal accounts to make both new and more experienced members more aware and conscientious of their decisions. One participant also stated it would be helpful to have training for positive coping mechanisms in the face of mental hazards.

Some participants reported receiving no safety training at all. Some participants reported that SAP training is not a mandatory for field activities and does not restrict them from conducting data collection. Participants who did not receive the training stated they were aware of it, but did not view it as necessary due to the nature of the data they were collecting (e.g. talking to community/officials or taking external pictures of buildings). One participant reported their reconnaissance organization (GEER) provided booklets about physical hazards and felt they were sufficient. They reported that such training could serve as a good foundation for newer members and as a "refresher" for the more experienced. Alternatively, some participants mentioned requiring certain training may inhibit teams, as those with more experience may be excluded because they did not undergo a particular training. Some participants stated experience should count in the place of training initially, but some form of annual training could also take place to improve latent skills.

All participants stated any training received focused more on physical hazards and impacts rather than mental ones. Additional focus on mental health hazards and impacts in pre-deployment training materials and upon return from severely affected locations was perceived to be beneficial by most participants.

PPE: All participants also dealt with excessive heat throughout the duration of their reconnaissance and reported wearing protective layers of lightweight clothing, and going to shaded areas and locations with air conditioning for respite and/or to prevent symptoms of heat-related illness and injury.

Debriefing: Most participants reported their organization emphasized the need for their members to be self-sufficient and self-contained while performing activities so that they do not impede on the resources designated for the affected community. All participants reported their organizations (e.g. GEER, EERI, Structural focus) held a debriefing of some kind, but mental and physical health were not mentioned. Some participants stated that in previous severe earthquakes there may have been mental health support, however for the Ridgecrest series there was not. Participants stated it would be beneficial to have support from their organization in the future.

Organizational support: Participants did not mention any role the organizations they worked for played in mental health support before, during, or after their trip. Some participants stated they could benefit from more mental health resources in the event of more devastating disasters in the future. However, funding and the size of organizations makes access to uniform quality resources difficult and restricted. Some participants reported acknowledgement of the potential mental impacts and that support would be beneficial and is needed from their organizations in the future. Some participants reported more lasting mental health impacts from prior reconnaissance missions to more severe disasters, such as in Haiti and New Zealand.

While participants in Ridgecrest were made aware of environmental hazards like snakes and brush in remote locations, no participants encountered any, and only a few received minor scrapes from desert brush while along the fault line. A few participants expressed they had mitigation strategies in place. For example, knowing the location of nearby hospitals and carrying snake bite kits, in the event that they or their team members were bit by a venomous snake. However, they were unsure if others had the same levels of preparedness or training. There was no mention of insect bites that participants could recall. Participants were not allowed to enter buildings with major damage, such as flooding, for safety reasons. All participants mentioned wearing or bringing more than one form of PPE in the event they needed it but did not utilize them at all times. Most participants stated it is normal to get around 5 hours or less of sleep during reconnaissance missions due to responsibilities in the field and the perishable nature of their data.

Many participants did not perceive a lot of situations to be threatening while collecting data in Ridgecrest. However, some mentioned experiences during prior reconnaissance trips where they did perceive situations as threatening. For example, participants who were in Haiti after the earthquake, reported that witnessing devastation and death was very traumatizing. They further explained they were unaware of whether their chosen coping mechanisms were appropriate, or if there were alternatives they could use. Another participant mentioned witnessing fellow individuals conducting disaster reconnaissance become trapped in unstable buildings while collecting data following previous earthquakes (e.g., Italy) made them more aware of potential hazards.

Strengths & Limitations

This exploratory, qualitative research study sought to gain knowledge of the effects of exposures faced by individuals conducting reconnaissance in Ridgecrest, California following the earthquake series on July 4-5, 2019.

The strengths of this study are the novel nature of the study and the sample size, which allowed for the achievement of key theme saturation. To the best of our knowledge, no prior study has explored the occupational health and safety, exposures, and impacts among disaster scientists in any environment. As such, this study provides a first look at occupational health impacts experienced by this population and provides an understanding of their experience following a large-scale earthquake in a developed country, which can be compared to experiences in other settings.

Although our sample size allowed us to achieve saturation, our study may be subject to non-response bias. Of the 51 disaster researchers who participated in reconnaissance contacted, only 20 (39.2%) positively responded to our invitation to participate. Of those who responded, two interviews could not be scheduled due to scheduling conflicts or nonresponse. As such, we interviewed only 35% (n=18) of researchers who participated in field-based reconnaissance and the EERI California Clearinghouse following the Ridgecrest earthquakes. It is possible that those who did not respond to our invitation were systematically different from those that did or had very different occupational health and safety experiences. However, the diversity of participants and achievement of saturation in key themes reduces these concerns.

In addition, interviews were conducted 6-7 months following the event, introducing the possibility of recall bias. We provided participants with an opportunity to review and amend summarized comments, both to assess the accuracy of the researcher's interpretation of their responses during the interview, as well as for the participant to add any key points missed in the discussion.

We also acknowledge that participants may be unaware of certain administrative controls implemented at the site, which may have influenced the hazards they interacted with and the topics they discussed in their interviews.

As in any qualitative study, the researcher's own biases may have influenced the style of question as well as the interpretation of responses. The research used an additional coder to improve codebook reliability, and three external experts reviewed the interview guide to ensure question clarity and instrument comprehensiveness. The researcher had no prior relationship with the participants.

Discussion

The results from our study indicate disaster researchers may experience a variety of safety and psychosocial hazards during field-based reconnaissance. While the Ridgecrest earthquakes were described as less severe than earthquakes of similar magnitude in terms of introduction of such occupational hazards, participants described several hazards encountered during this and prior field-based reconnaissance trips. They identified the opportunity for training and administrative controls, such as the

buddy system, to reduce exposure to and impacts of these hazards. Here, we discuss several key findings from our study and suggest recommendations for future research and practice.

Findings from our study demonstrate disaster researchers experience a variety of occupational health and safety exposures. To the best of our knowledge, this study is the first of its kind to explore the perceived health and safety exposures and impacts to disaster researchers. This work builds on prior literature that has illuminated occupational health and safety risks experienced by disaster workers[7,10,18,20]. For example, participants in our study described concerns about snake bites while working in remote locations. A cross-sectional survey-based study of Coast Guard members responding to Hurricane Katrina found that the most common physical exposures were animal bites and scratches along with flood waters (e.g. exposure via submersion, ingestion, or inhalation) [6]. Future research is needed to understand health and safety exposures associated with severe disaster environments. We also recommend that pre-deployment training focus on hazards specific to the location teams are being deployed to so that they have increased self-efficacy to mitigate hazards they face.

Results of the study showed that disaster scientists underutilized PPE while performing reconnaissance in affected areas. Most participants in our study reported wearing minimal PPE for non-heat related hazards, and experienced participants also reported not wearing appropriate PPE in locations where they should have. Additional research regarding PPE compliance and its determinants should be done in reconnaissance locations. Additionally, programmatic interventions, such as checkpoints, to promote accountability for PPE compliance among individuals performing reconnaissance is recommended.

While no participants in our study reported experiencing any heat related health impacts, they did report using sunscreen and hats, as to protect themselves during reconnaissance. Participants also reported temperatures were well over 100°F throughout the duration of their trip and noted as the biggest hazard throughout the experience. A few participants noted wearing long lightweight protective clothing for protection, but most participants used cool water, shaded areas, and car air conditioning as additional protective measures from heat. Prior literature reveals workers wearing PPE and working in excessive heat environments rarely seek medical treatment for their heat-related illness symptoms [7]. Individuals performing reconnaissance should be trained on the potential effects of excessive heat conditions and ways to reduce risk. Moreover, PPE use recommendations (e.g., recommended breaks) should be mindful of potential complications of PPE use in high heat environments.

Mental health impact awareness and resources

Results from the study also indicated that there is a lack of awareness about mental health hazards and impacts among disaster researchers and their organizations. Participants who interacted with impacted members of the community in Ridgecrest reported they were affected by the experience. Many participants mentioned that coping with these encounters or the effects of them are beyond the scope of any training they had received. Steps should be taken to help them properly understand and mitigate mental health hazards and their impacts in the future.

While participants described being “secondary responders” versus first responders, traumatic exposures and the potential mental health impacts may be similar and warrant additional research and practical attention. Prior research on disaster responders reaffirms concerns about potential mental health impacts

of disaster researchers. For instance, a review of data from Japanese Defense Force members found that indirect trauma is more likely when responders worked around affected community members. The study also found that indirect exposures resulted in more mental health impacts than direct exposures [8]. An additional study found that a majority of responders still had remaining mental health impacts such as PTSD and distress months after their missions finished [9]. The same study also explained that the results of the survey were likely due to compounded effects of previous disasters and not solely from the disaster the study focused on [9]. This highlights that effects of working in multiple disaster locations are not independent of each other and can influence the magnitude of impacts over time. This alignment with the results of prior literature reaffirms the need for additional studies on mental hazards and impacts faced by disaster researchers. Organizations are recommended to provide mental health resources both before and after reconnaissance to the best of their ability.

Participant's organizational or professional goals require them to work quickly so they can disseminate information and progress in their fields which may cause mental and physical health impacts. Some did mention that organizational consideration and acknowledgement of consequences of workload (e.g., fatigue and burnout) would be beneficial. We recommend organizations review field-based activities and make efforts to eliminate unnecessary tasks. Moreover, national, and organizational investment in reconnaissance activities may allow for additional researchers to participate, allowing for more distributed tasks. However, systemic issues inherent in the academic system (e.g., "publish or perish") may dissuade researchers from distributing or sharing tasks. Additionally, positive mental impact coping strategies should be taught alongside physical hazard mitigations strategies. Low cost options include web-based training designed to promote recognition of, mitigation of, and adaptation to mental health exposures and impacts.

Improvement of self-efficacy and training requirements

General training and experiential opportunities for emerging disaster researchers may increase their health and safety during field-based reconnaissance. Experienced participants stated they were able to identify and mitigate hazards in Ridgecrest, and are confident in their ability to do so in future disasters, and noted their experience as the primary reason for their perception of their self-efficacy in this regard. Less experienced participants, however, were not as confident in their ability to identify and mitigate hazards in future disasters as damage of Ridgecrest is less than what is usual in a M7+ earthquake series. Most participants, however, did state Ridgecrest was a good introduction to field reconnaissance because it provided a safer environment for them to apply their field skills, but may provide false expectations for disasters in the future. Programs like the Earthquake Engineering Research Institute's Learning from Earthquakes' Travel Study Program, which attempts to provide reconnaissance experiences to early career disaster researchers and professionals [13], offer opportunities to address this disparity by integrating health and safety training into participant experiences. .

While our study provides a first look at occupational health and safety experiences of individuals performing disaster reconnaissance, future research should include more comprehensive and long-term assessments of health impacts. Prior literature has explored the physical and mental health impacts of hazards on first responders in disaster locations, and has demonstrated that both physical and mental health impacts have the potential to affect the responder years after the event has occurred [4,17]. This alludes to the potential for more severe and long-term health impacts among those performing field-based

reconnaissance, and the need for more comprehensive exposure assessment and longitudinal health research.

Conclusion

Disaster researchers and experts participating in field-based reconnaissance perceived many exposures that have potential to result in occupational health and safety impacts. Common physical and safety hazards encountered included heat, brush, and falling-object hazards. Psychosocial hazards included interactions with affected communities and long work hours. While their experiences following this particular event were described as less severe than prior disaster response efforts, similarities to experiences of responders and volunteers following prior disasters indicate that additional training and research attention is needed in this area.

Next steps for disaster research practice: Training, particularly around mental health impacts, was identified as an immediate opportunity to improve health and safety among this population. While participants described barriers to mandatory training requirements, at minimum, we recommend that organizations funding or organizing reconnaissance activities prepare disaster researchers with information on potential physical and mental health impacts, mitigation strategies, and coping mechanisms, as well as access to PPE and resources for mental health. While training and informational materials may be targeted to early career researchers or individuals new to reconnaissance, they should be accessible to individuals performing reconnaissance at all levels. We also recommend web-based or "tailgate"/"on-the scene" training be supplemented with classroom training that includes simulation, focused on maintenance of critical health and safety skills and mitigation strategies that might be otherwise difficult to maintain.

Next steps for research on disaster reconnaissance: Additional monitoring and longitudinal studies that focus on the exposures of individuals performing reconnaissance various disaster environments are indicated. Mental health hazards and impacts should also be further assessed to better understand other contributing factors and outcomes and inform recommendations for mitigation strategies in the future. Additional studies should be conducted to assess the effectiveness of training, specifically those focused on mental health impacts and mitigation.

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APPENDIX

Appendix A: Recruitment emails

Initial contact email
Subject: Invitation to Participate in Study on Occupational Health & Safety of Disaster Researchers

Hello [Insert name],

My name is Brianna Willis and I am a Master of Public Health candidate at the University of Washington Department of Environmental and Occupational Health Sciences. I am contacting you to see if you would be willing to participate in a short (30-60 minute interview) as part of my thesis research.

The goal of this study is to identify and describe occupational health hazards and outcomes (e.g., illness and injuries) faced by disaster reconnaissance researchers and to also explain opportunities to mitigate such health and safety impacts. We plan to use this study to address knowledge gaps in disaster science literature on the occupational exposures of disaster researchers in earthquake locations specifically in Ridgecrest, California.

I am interviewing disaster reconnaissance researchers who participated in reconnaissance efforts following the 2019 Searles Valley earthquake sequence. Given your participation in reconnaissance work following these events, I am writing to see if you would be willing to participate in an interview. The interview is expected to take 30 - 60 minutes to complete and will take place over the phone on a date and time that is convenient for you. You may review interview questions prior to the interview.

Interview participation is completely voluntary. Data you provide will be anonymized; nothing you say will be attributed to you without your explicit consent. The information gathered across all interviews will be qualitatively analyzed and used to produce a written report, publishable manuscript, and/or conference presentations. We also hope to use the results to inform the development of tools and resources to mitigate occupational injuries and illnesses among disaster reconnaissance workers.

We will provide all study participants with a copy of the final report.

Please respond **within one week** (Insert date) about your willingness and ability to participate in an interview. If we don't hear from you in one week, we will follow up by email or phone.
If you agree to participate, we will contact you to schedule a time for a 30-60-minute interview. If you have any questions, do not hesitate to contact us. We would like to thank you in advance for your consideration and input to this study.

Best regards,

Brianna Willis
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One-week follow-up
Subject: Reminder: Invitation to Participate in Study on Occupational Health & Safety of Disaster Researchers
Hello,

I am writing to follow up on my invitation to participate in our study on the occupational health of disaster researchers during the 2019 Ridgecrest Earthquake. Please see our attached previous email for a reminder of the aims and purpose of the study.

If you agree to participate, we will contact you to schedule a time for a 30-60-minute interview. If you have any questions, do not hesitate to contact us. We would like to thank you in advance for your consideration and input to this study.

We look forward to hearing from you,
Brianna Willis
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Scheduling
Subject: Scheduling interview for Occupational Health & Safety of Disaster Researchers Study
Hello [insert name],

Thank you for agreeing to participate in our research study on the occupational health of disaster researchers following 2019 Ridgecrest earthquakes.

This email is to schedule your interview date and time. The interview will occur over the phone. The interview is designed to take between 30 and 60 minutes to complete and will take place over the phone. Can you **please provide three 60-minute windows** that you are available for the interview between February 7, 2020 - February 14, 2020? **Please also provide the best phone number to reach you at these times**. I will respond within 48 hours confirming your interview date/time followed by a calendar invitation for your interview slot and a copy of interview questions to better help you prepare for your interview.

Best regards,
Brianna Willis

…

Interview Confirmation
Subject: Confirming interview for Occupational Health & Safety of Disaster Researchers Study

Hello [insert name],

Thank you for your response. your interview has been scheduled for [insert date and time]. I have attached the interview questions for your reference. Please note that these questions are intended to guide, not limit, the conversation.

Please let me know if you have any questions. I look forward to our interview on [insert date and time].

Best regards,
Brianna Willis

One week prior to interview
Subject: Reminder: Interview for Occupational Health & Safety of Disaster Researchers Study
Hello [insert name]

Thank you again for agreeing to participate in our study on occupational health considerations of disaster researchers following the 2019 Ridgecrest earthquakes. Your interview is scheduled for [insert date and time] and will last approximately 30-60 minutes.
Please let me know if you have any questions.

Best regards,
Brianna Willis
Member Checking

Subject: Review of the Interview summary for Disaster Researchers Study

Hello [insert name]

Thank you for your participation in the Occupational Health & Safety of Disaster Researchers Study.

As mentioned in our interview I am sending this email with an attachment of the main points taken from your interview. Please review this document and return it with any changes needed in **two weeks (2/24).** If no changes are received within that period, we will be taking the information as interpreted in the document.

Please note this document is not a transcript but a summary of the main points taken from your interview.

Do not hesitate to contact me if you have any questions.

Best,
Brianna Willis

Appendix B: Interview Guide

Interview Guide:
Perceived Exposures of disaster scientists that participated in Ridgecrest earthquake reconnaissance

1. **Welcome**

Thank you for agreeing to participate in our study. We've asked you to participate because you were involved in reconnaissance work following the earthquakes that took place in Ridgecrest, CA on July 4th and 5th, 2019. We are interested in understanding the occupational health and safety hazards and impacts among disaster scientists who participate in field reconnaissance activities.
The purpose of this interview is to describe you and your team's occupational health and safety-related experiences during your reconnaissance work following the 2019 Ridgecrest earthquakes. We'd also like to hear your thoughts on potential recommendations that could minimize occupational health and safety issues during future reconnaissance, including training and resource provision.

2. **Explanation of the process**

We are using an interview format to help understand the context behind the answers you will provide to our questions, as we believe they will provide a more in-depth understanding than a written survey can provide. There are no wrong answers.

We will be taking notes and recording the interviews. Interviews will be professionally transcribed for data analysis. Interview data that has been de-identified may be placed in a data repository for use in future research (for example, in DesignSafe) or to answer alternative research questions. Your name or contact information will not be associated with any data that is shared in such a repository or with other researchers.

The findings may be written into a report or manuscript for publication in a peer-reviewed journal. We will not refer to you by name in any report or publication without your explicit written consent.

Your participation in this interview is completely voluntary and you may opt to stop at any point in the interview process and leave the study at any time. You will not be penalized for not answering questions or leaving the study. We will provide you with a complete copy of our results at the conclusion of the study.

In the next few weeks, I will send you a summary of the key points gleaned from your interview. I will ask that you review them and let me know if I accurately captured the perspectives you shared within two weeks of receiving that email.

3. **Questions and consent**

Do you have any questions before we begin?
Do you consent to be a participant in our study? (ask participants to provide a verbal "yes".)
Do you consent to the recording of this interview?

4. **Discussion**

Firstly, we would like to hear about you and your team's experience before, during, and after the 2019 Ridgecrest earthquakes that occurred July 4th - 5th.

Can you tell us about any experience where you have conducted reconnaissance before Ridgecrest?

Now, we'd like to talk specifically about your reconnaissance work following the Ridgecrest earthquakes.

- What was the goal of your reconnaissance activities?
    - Can you tell me your group's goals?
    - Can you tell me your personal goals if they differed?
- When, and for how long, were you in the field?
- Were you alone or with a team?
    - What was the general composition of your team?
    - If there were students how were they incorporated into your team?
    - How did the composition and dynamics of your team affect how you worked in Ridgecrest?
- Can you tell us about your typical daily activities during this reconnaissance trip?

<u>Exposures</u>

- Where did you stay? (Prompts: a hotel, campsite, colleague, or friend's house)
- Were you able to confirm the safety of your accommodations in advance? How?
    - Were your accommodations damaged by the earthquake?
    - If yes, did you know before you arrived?
- Where did you access most of your meals?
    - Did you have any problems accessing food or confirming that it was safe and nutritionally healthy food?
    - If you brought your meals, did you have access to resources to store, prepare, and make them safely?

Now I want to ask you a bit about what you encountered while in the field. Please think broadly. This could be anything that impacted your health or safety in the location reconnaissance was performed.

- Were there any physical hazards in the locations you were working? Prompts: things that potentially could've been tripped over, shortages in food and or water supply, walking in or around buildings with poor infrastructure?
- Did you encounter any ergonomic issues that impacted your comfort while performing your tasks?
    - Prompts: repetitive motions, heavy lifting, or loud noise while performing tasks
- Were there chemical or biological hazards in any of the locations you were working?
    - Prompts: fumes released from pipes or buildings, close proximity to people with infectious illnesses, eating unrefrigerated or otherwise unsafe food, heat-related injuries or illnesses or anything along those lines?
- Did you experience anything that you think would have the potential to impact a disaster scientist's mental health or wellbeing?
    - These are things such as the fear of aftershocks, fear of instability in buildings accessed, long days of work, team conflict, observation of loss or death
    - Try to think of this question from more of a personal perspective and avoid projections.
- *For informants that had prior reconnaissance experience:* Are the exposures you described consistent with your experiences during prior reconnaissance trips? Why or why not?
- Did you encounter anything else that impacted your health and wellbeing that we didn't cover?

Nature of Injuries

- Did you or any members of your team experience any illness or injuries related to your reconnaissance work?
- Were any of your or your team members' pre-existing conditions exacerbated because of your reconnaissance work?
- If not: Based on the exposures, you described what types of things do you think could have happened? Did you have any close calls? What do you believe could have been the worst possible mental or physical health impact you or a member of your team could have experienced?
- Did you or any members of your team experience any signs of distress or anxiety?
- Upon your return from Ridgecrest did you attend a debriefing or after-action report meetings?
    - *If yes:* Were mental and physical health addressed during this time?

Influencing factors

- Do you believe you were equipped with the knowledge and skills to approach different hazards? Why or why not?
- Before you were in the field, did you think you would be exposed to things that would affect you or your team's health and wellbeing during reconnaissance?
    - Could you possibly describe a situation where you felt unprepared?
- Did you complete any preparation or take any special precautions to minimize the likelihood of experiencing occupational health or safety impacts associated with your reconnaissance work? (Prompts: Did you participate in any training? Wear any PPE? Participate in post-event debriefings)
- *If yes:* Can you tell me a little more about why you decided to participate in [this activity]]?
    - Did your employer or professional association require you to participate?
    - Did your employer or professional association provide you with optional field health and safety resources?
    - *If no:* What might have been useful to prepare you to have a healthy and safe reconnaissance trip?
- How do you think the likelihood of your team experiencing the illnesses and injuries you described could be decreased in the future? Prompts: For example, is there any specific training, PPE, or guidance that could have been helpful
    - If the respondent described multiple injuries and illnesses in their responses to questions in the "Nature of Injuries" section, prompt him/her to describe ways to reduce the likelihood of occurrence of each group of illnesses or injuries. For example: "You mentioned several mental health impacts that were experienced by members of your team. How do you think the likelihood of experiencing mental health impacts during reconnaissance work could be reduced?
- What do you think would increase the likelihood of future disaster researchers engaging in occupational health and safety preparation prior to conducting reconnaissance?
- How do you think your prior experience conducting reconnaissance influenced your health and safety during this trip?

Is there anything else you would like to share about your reconnaissance experience?

Would you mind if we contact you if we have additional questions in the future?

Appendix C: Codebook

Perceived Exposures of Disaster Scientists Codebook

Name	Description
Danger or Threat	A situation or item that has the potential to cause dread, bodily harm, or alter a human life mentally or physically.
Disaster Risk	The event of being exposed to a hazardous disaster-affected environment that has a non-zero probability of causing harm to infrastructure or people. **The event of interacting with a hazardous disaster-affected environment that has a non-zero probability of causing harm to infrastructure or people.**
Dynamics	Pertains to the dynamics of interactions within the groups or organization in the field and how it may affect the health and safety
Experience	related to their prior or current experiences related to reconnaissance. And how it affected their perceptions. -Amended 4/18
Exposures	The state of being in contact with a hazardous environment that could allow for the opportunity to experience risk.
Goals	**Pertaining to personal or organizational goals during recon**
Hazard	A situation regarding an activity that has the potential to cause injury or loss of life through active interaction either by itself or in combination with exposures and risks. **A situation regarding an activity that has the potential to cause injury or loss of life but there is no interaction with it. Opposite of Risk definition**
Hindsight	**everything related to things that were learned in reflection of this recon or previous recons**
Influencing Factors	Factors such as the type of disaster, type of responder, length of membership, living environment, and work environment can influence the nature of reconnaissance member injuries. **Pre-existing conditions is also included**
Interesting Quotes or events	Interesting quotes or events that were mentioned in the interview that got your attention

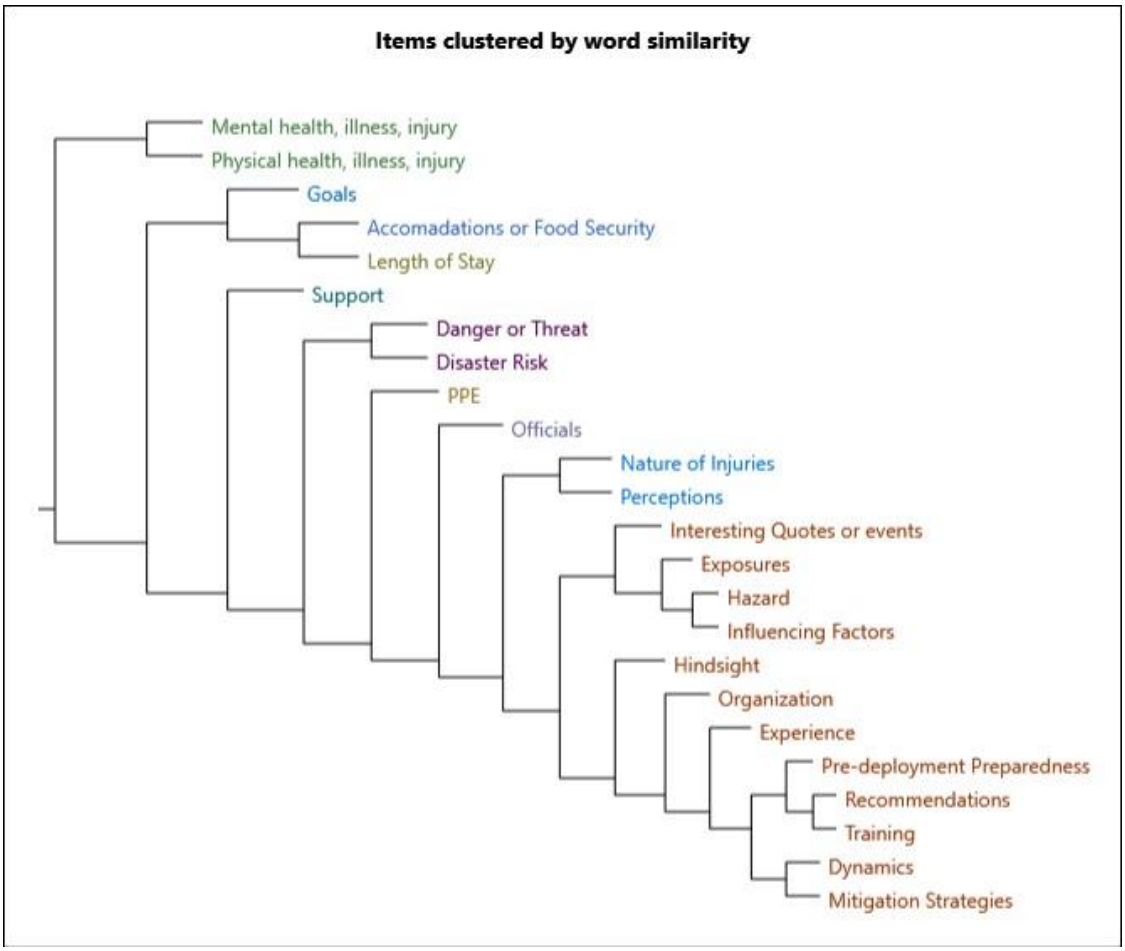
Length of Stay	**the length they stayed in Ridgecrest**
Mental health, illness, injury	Information related to the altered mental health that resulted in negative alterations to mental health that had the potential resulted in mental illness such as PTSD, depression, anxiety, panic disorders, etc.
Health	Topics that pertain to mental hazards that have caused an alteration to mental health or mentions deviating from a "normal" mental state
Illness	Information related to or from situations that resulted in mental illness
Injury	Information related to or from situations that resulted in mental injuries
Mitigation Strategies	Topics related to active engagement in strategies that were used to control/ mitigate the hazard, risk, or exposure they have encountered.
Nature of Injuries	The nature of injuries can be categorized into physical and mental categories. Physical injuries may be immediate, short-term, or long-term. Mental injuries or illness can be categorized as immediate, short-term, or long term during or after their deployment.
Officials	Pertains to interactions, perceptions, and/or roles of officials (local, government, etc.) in the disaster location.
Organization	Related to organizational structure in terms of goals, expectations, and standards for conducting reconnaissance work.
Perceptions	Can be related to perceptions that do not fit into threat, stakeholder, and/or protective actions
Protective Action	The perception related to the situation that poses a threat to the individual they must decide on an action to protect themselves.
Stakeholder	The stakeholder in this framework can either be an individual or the organization. Stakeholder perceptions are related to how their goals, expectations, and standards that can influence research.
Threat	The appraisal involves an assessment of threat and self- efficacy to decide on either the fear or danger control process.
Physical health, illness, injury	Information related to the altered physical health that resulted in negative alterations to physical health that resulted in injuries or illness such as abrasion, bruises, fractures, diabetes, etc.
Health	Information related to or from situations that resulted in effects to physical health

Illness	Information related to or from situations that resulted in physical illnesses
Injury	Information related to or from situations that resulted in physical injury
PPE	Related to Personal protective equipment regardless of whether they wore it or not
Pre-deployment Preparedness	Information related to self-efficacy and confidence in performing and engaging in acquired knowledge and skills from training
Recommendations	**Their training recommendations**
Support	Topics related to support systems following deployments, social support, mental health support groups.
Training	Skills or knowledge acquired prior to deployment that include but are not limited to field training, live simulation, power points, reference guides

Bolded text are amendments made after co-coding.

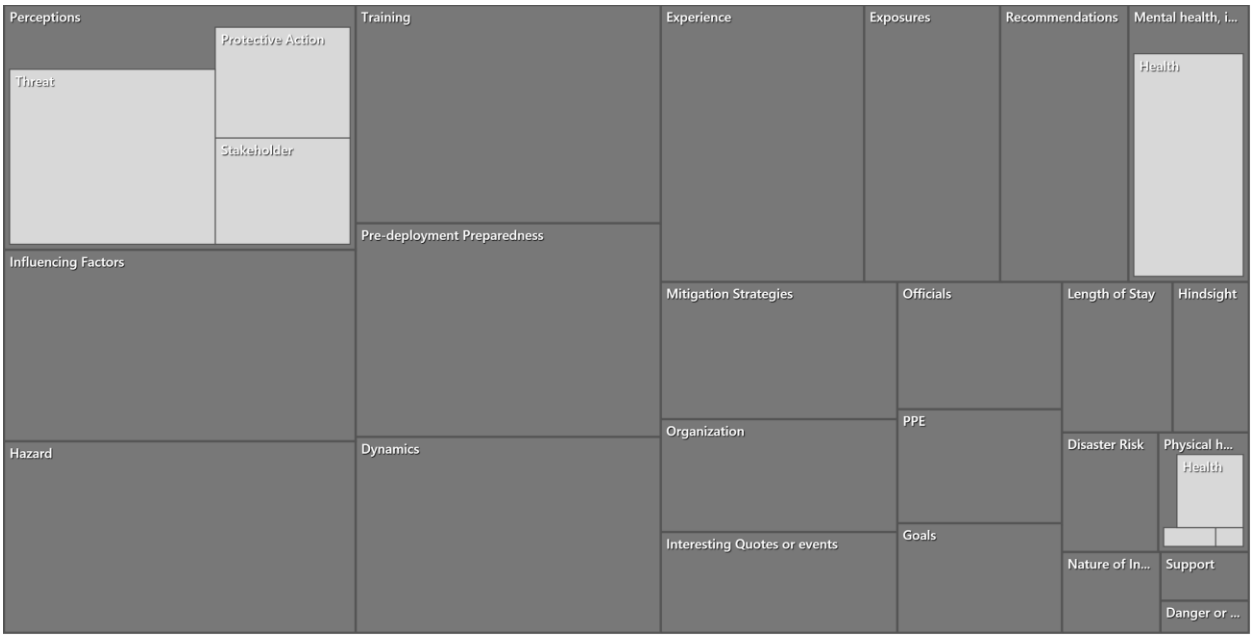
Visualizations

Appendix D: Relationship Chart



This visualization shows the relationships between the codes used for this study. Unsimilar codes are further apart while the similar ones are closer and grouped together on branches.

Appendix E: Hierarchy Chart



This visualization shows a breakdown of the consistency of how codes were used. The larger the square the more frequently it is you. Through this visualization you can see that the most frequently used codes were hazard, influencing factors, and pre-deployment preparedness. The least used codes were physical health, injury and illness, length of stay, and support.