Disaster Medicine and Public Health Preparedness

www.cambridge.org/dmp

Healthcare and Social Organizations' Disaster Preparedness, Response, and Recovery Experience: Lessons Learned From Hurricanes Irma and Maria

Carlamarie Noboa-Ramos MS, PhD[1], Yadira Almodóvar-Díaz MPH, DrPH[2], Emma Fernández-Repollet PhD[3] and Kaumudi Joshipura ScD[1,4]

[1]Center for Clinical Research and Health Promotion, School of Dental Medicine, University of Puerto Rico Medical Sciences Campus, San Juan, PR, USA; [2]Independent Consultant; [3]Center for Collaborative Research in Health Disparities, University of Puerto Rico Medical Sciences Campus, San Juan, PR, USA and [4]Department of Epidemiology, Harvard TH Chan School of Public Health, Boston, MA, USA

Original Research

Cite this article: Noboa-Ramos C, Almodóvar-Díaz Y, Fernández-Repollet E, Joshipura K. Healthcare and social organizations' disaster preparedness, response, and recovery experience: Lessons learned from Hurricanes Irma and Maria. *Disaster Med Public Health Prep*. **17**(e306), 1–9. doi: https://doi.org/10.1017/dmp.2022.272.

Keywords:
healthcare and social organizations; preparedness; response; recovery; hurricanes

Corresponding author:
Carlamarie Noboa-Ramos,
Email: carla.noboa@upr.edu.

Abstract

Background: Healthcare and social organizations (HSOs) are first respondents after natural disasters. Hence, their preparedness and resilience are critical components for addressing future disasters. However, little is known about HSOs' experiences prior to, during, and after hurricanes.

Objective: To describe preparedness, response, and recovery experiences from hurricanes Irma/ Maria among HSOs in Puerto Rico and the US Virgin Islands.

Methods: Using a convenience sample, semi-structured interviews were conducted with 52 key-informants. Content analysis for common and recurring themes and patterns was performed by HSO type.

Results: Most HSOs (80.8%) had a preparedness plan and 55.8% responded providing emergency supplies. HSOs' human resources (61.2%) was the main recovery facilitator/ enabler, while 36.5% identified the lack of economic resources and the lack of an integrated emergency plan as the top barriers. The main lesson learned include understanding the need to make improvements to their emergency preparedness plans (56.3%), and to establish an integrated/ centralized plan between relevant parties.

Conclusion: Lessons learned after hurricanes allowed HSOs to identify gaps and opportunities to become more resilient. Infrastructure capacity, human resources, communication systems, and economic support, as well as training, partnerships, and new policies should be defined, revised, and/ or integrated into the HSOs' preparedness plans to mitigate the impact of future disasters.

Introduction

Hurricanes Irma and Maria destroyed vital infrastructure (e.g., power, water, and communications systems), and disrupted access to food, healthcare, and medications across Puerto Rico (PR) and the US Virgin Islands (USVI). Hurricane Irma (Category 5) passed over the USVI on September 6, 2017 and came close to PR on September 7, 2017, affecting mainly regions of PR, and leading to significant flooding, widespread power outages, and water supply disruptions for several days.[1,2] After 2 weeks, on September 20, 2017, hurricane Maria directly hit the USVI as Category 5 and PR as Category 4. Peak wind speeds of over 150 miles per hour were recorded on these islands.[3] These hurricanes were the most intensive storms to make landfall on both islands since 1928 and had major detrimental impact on the population's health.[4]

The healthcare impact caused by these hurricanes immediately became apparent.[5–10] In December 2017, the PR Government officially reported 64 deaths,[5] however, a Harvard University study estimated over 4600 deaths.[7] George Washington University's study estimated 2975 deaths,[8] a toll later accepted as official. The mortality rate in PR after hurricane Maria increased by 62% compared to the 2016 figures.[7] Officially, 5 USVI deaths were attributed to these hurricanes.[11] Hurricane Maria caused an estimated $90 billion in damages across PR and the USVI, making it the third costliest hurricane in US history.[12]

Healthcare and social organizations (HSOs) are the lifeline for prevention, diagnostics, treatment, and rehabilitation for both physical and mental health. After disasters, HSOs serve as first responders for injured and ill members of an affected population, and often fulfill unmet social needs, particularly for patients on life sustaining medical equipment who may have lost their homes, power and/ or water supply services. Depending on the organization's scope and capabilities, some may provide primary and secondary services, while others may deliver tertiary

© The Author(s), 2023. Published by Cambridge University Press on behalf of Society for Disaster Medicine and Public Health, Inc. This is an Open Access article, distributed under the terms of the Creative Commons Attribution licence (http://creativecommons.org/licenses/by/4.0/), which permits unrestricted re-use, distribution and reproduction, provided the original article is properly cited.

healthcare and preventive efforts.[13] Organizations also serve as catalysts for vital information, education, community assessment, and outreach. Thus, resiliency and preparedness of these organizations are necessary for addressing future disasters.[14]

Generally, HSOs are critically dependent on their suppliers, key customers, and target populations for their continued operations and survival. To effectively manage their resilience, these organizations must look beyond their own capacity, and consider the interdependence of other related entities.[15] The challenge has been how to achieve the collaboration and commitment required to collectively prepare for future disasters, rather than doing it in an individual manner.[16] This type of integrated organizational planning and preparation can make a significant difference in keeping communities safe, and in continuing operating and responding to future emergencies.

It is critical to understand the best practices and lessons learned by organizations in relation to disaster preparedness, response and recovery efforts in order to improve preparedness, mitigation, response and recovery for future disasters.[17] Few studies have highlighted hurricane preparedness and response efforts of HSOs in PR and the USVI.[11,18] None explored recovery efforts, and none examined the experience of both US territories simultaneously. This study expands this body of evidence by describing the preparedness, response, and recovery experiences from hurricanes Irma/Maria among healthcare and social organizations in PR and USVI, and highlights the interconnections and lessons learned that may be applicable to similar organizations operating in comparable contexts and geographic areas.

Methods

The PREPARE study was launched to identify key vulnerability and resiliency factors among HSOs in PR and few organizations in the USVI. A convenience sample was used for the organizations and key-informants.

Participants

The eligibility criteria for HSOs included: (1) providing healthcare or social services, or (2) being actively involved in the disaster preparedness, response, and recovery phases of hurricanes Irma/Maria in PR or USVI. We excluded HSOs that were not actively participating in any of these phases in the targeted US territories. We identified key organizations according to the eligibility criteria through an interactive process with local and external experts. A total of 113 HSOs comprised the pool of potential participants including Federally Qualified Healthcare Centers (FQHCs; n = 7), government-owned hospitals (n = 8), non-profit and for-profit hospitals (n = 14), and professional associations (n = 6), as well as CBOs (n = 11), homecare and nursing homes (n = 10), dialysis centers (n = 4), and local and federal government-agencies (n = 16). The HSOs also include emergency relief organizations (n = 11), pharmaceutical companies (n = 3), health insurance companies (n = 3), and other key grassroots organizations (n = 20). HSOs included locations in North, Metro, East, as well as Central, South, and West areas of PR as well as USVI (Saint Croix, St. Thomas, and St. John). We aimed to recruit 50 organizations and recruited 52 given our multiple simultaneous outreach efforts. All HSOs provided services to the general population and medically underserved populations across all age-groups. Some HSOs supported specific target audiences such as people with disabilities, chronic illness, homeless, and undocumented migrants.

For each HSO, a key informant was selected. Key informant inclusion criteria were: (1) aged 21 or older; (2) holding a senior or executive level position or being a consultant in the HSO; and (3) having actively participated in the preparation, response, and recovery phases of the organization after hurricanes Irma/Maria in PR or USVI. We excluded participants who: (1) had been working in the HSO for less than 12 months prior to hurricane Irma, and (2) who were not working in the HSO during and after the hurricanes.

Procedures

Data was collected from May 13, 2019 to August 17, 2020. Potential key-informants were contacted via email and telephone to invite them to participate in a semi-structured face-to-face interview conducted by a trained interviewer. Due to COVID-19 restrictions, 7 interviews were conducted using the Zoom platform. Each interview took approximately 1.5 hours (range: 1.00 -2.25). For those lasting over an hour, a 10-minute break was taken to ensure high quality of the interview. All interviews were conducted despite breaks, all were engaged in the discussion, and none of the key-informants exhibited or mentioned feeling fatigue.

Data collection included a semi-structured guide of 26 questions regarding the overall experience of the organization before, during and after the hurricanes (Appendix A). Open-ended questions were developed based on the experience and with input of local and external experts. The services, resources, target population, and partners, as well as preparedness efforts of the HSOs prior to the hurricanes were explored. HSOs emergency response efforts were assessed including the disaster response services/ support and challenges that the organization and target population faced. Factors that facilitated the recovery of the organization, the greatest barriers to recovery, and resilience and preparedness were also assessed. 2 mock interviews were conducted to assess the validity of the data collection instrument and procedures. All interviewees accurately understood the open-ended questions. Based on mock interviewees' feedback, 3 questions (11.5%) were reformulated to improve clarity. Importantly, all interviews, including the mocks, were conducted by the same interviewer, to ensure consistency, reduce variability, and minimize bias.

The interviewer was accompanied by a note-taker that took computer-aided notes. All interviews were audio-recorded to increase the accuracy of the data obtained, and for analysis purposes. Data was transcribed, then reviewed and organized by the interviewer in a database that was color coded by organization type. This study was approved by the Institutional Review Board of UPR-Medical Sciences Campus. Informed consent was obtained from all study subjects.

Data analysis

Qualitative analysis was performed by 2 investigators. Inductive and deductive approaches were used.[19,20] Coding process was applied according to the literature and participants experiences.[19–22] A list of codes according to the literature about disaster preparation, emergency response, and recovery efforts was prepared. Each researcher performed a line-by-line analysis of all transcripts to identify these codes as well as common and recurring themes and patterns that emerged to the data,[19] including interconnections and outliers. We then compared the separate coding and developed an integrated and refined set of themes and codes. After consensus on the themes and codes was reached, a codebook

https://doi.org/10.1017/dmp.2022.272 Published online by Cambridge University Press

was developed. Then, we determined the counts of each code/ theme from all interviews. Themes that represented less than 3 counts were excluded for analysis purposes.

HSOs were categorized as: (1) Service delivery organizations (SDOs) providing mental, social and/ or physical health services to individuals, families, and communities. These included hospitals, FQHCs, dialysis centers, and homecare/ nursing homes; (2) Emergency, philanthropic, and other support organizations (EPOS) assisting institutions and communities with the emergency preparedness, response, and recovery efforts. These included emergency response and relief organizations, professional associations, pharmaceutical and health insurance companies; (3) Government agencies (GAs) that oversee developing and implementing public policies, regulations, and overseeing the delivery of healthcare services including PR government and federal entities. Results are presented by common themes and organization type.

Results

Participants

Most participants (94.2%) were based in PR. Around 52% of HSOs were SDOs, followed by EPOS (34.6%), and GAs (13.5%). Key informants interviewed were presidents (15.4%), executive directors (57.7%), administrators (7.7%), and program directors/ managers (19.2%). Most were female (69.2%) and reported being in that position in their HSO for at least 5 years (94.2%).

Disaster preparedness experience

Most HSOs (80.8%) and SDOs (96.3%) reported having a written emergency preparedness plan prior to hurricanes Irma and Maria; while all GAs (100%) reported the same as this is required by law and by accrediting agencies. Only 50.0% of EPOS mentioned having a written preparedness plan. Some organizations did not have a formal written emergency plan because they 'used the government's plan' or later realized that they only 'had some components,' but not a complete action plan.

Many of the HSOs, all EPOS (100%), GAs (71.4%), and SDOs (69.2%) with a written preparedness plan reported it included a communication strategy (78.6%). These strategies included clear lines of communication for internal and external stakeholders during an emergency, alternative communication methods to be used in power outages and in instances when internet services were disrupted, as well as having redundancy of their internal systems, and technologies. Among organizations that had a communication plan, 90.9% recognized that their plans had significant gaps and were not adequately executed.

In preparation for hurricane Maria, 78.3% of HSOs mentioned that they activated their emergency preparedness plan (Table 1). Over 50% of the HSOs protected their facilities and equipment, and checked their level of supplies (e.g., food, water reserves, and power generators). Additional actions taken in preparation included re-scheduling the staff shifts (21.7%) and supporting staff for their own preparedness plan (17.4%). Although most organizations reported having emergency plans, they expressed challenges and limitations to effectively respond and to mitigate the impact of the hurricanes, particularly lacking preparedness for the impact and damage of a category 4 or 5 hurricane. According to the participants, the major limitation of the plans was the limited strategies and resources included to ensure communication during and after a disaster.

Disaster response experience

Challenges encountered

The top challenge experienced immediately after hurricane Maria (Table 2) by most HSOs was lack of communication services (82.7%). The next top 2 challenges reported varied across HSOs. For SDOs, the main challenges were limited accessibility of critical supplies (48.1%), and lack of utilities (44.4%) such as water, and electric power. For EPOS, the main challenges were the inability to identify the status and needs of staff, target populations, and/ or providers (27.8%), as well as limited access to roads and transportation routes (27.8%). For GAs, 57.1% reported damages caused to infrastructure while 57.1% also reported an inability to identify the status and needs of staff, target population, and/ or providers as the most frequent challenges encountered.

Disaster response services to target populations

Within the first 24 and 72 hours after hurricane Maria, 55.8% of organizations deployed emergency supplies, food, and water to their target populations (Table 3). The most frequent disaster response services delivered by SDOs and GAs were healthcare support including medical (70.4%) and pharmacy services (57.1%). HSOs also contributed to conducting community outreach and damage assessments, as reported by SDOs (37.0%); EPOS (55.6%); and GAs (28.6%). Some EPOS (27.8%) also reported being engaged in the provision of medications and setting-up triage units to manage patients. Local and Federal GAs were mostly (42.9%) focused on evacuations/ transportation of patients and communities, as well as evaluating the health status and wellbeing of patients and communities (Table 3).

Disaster response services to their human resources

The most frequent (61.5%) disaster response effort offered by HSOs, excluding GAs for their staff, was emergency supplies such as food and water (Table 3). The second most frequent response effort provided was economic support, as reported by SDOs (37.0%) and EPOS (66.7%). For GAs, the main response efforts offered to their staff were social and mental health support (57.1%), and healthcare services (42.9%).

Disaster recovery experience

Facilitators

The main enabling factor reported by most HSOs (61.2%) post-hurricane Maria recovery was the support and commitment of their staff (Table 4). Additional factors reported by SDOs were availability of economic assistance mainly from donors and federal agencies (44.4%), and improvements to their facilities and equipment (37.0%). For EPOS, networks, and partnerships support (43.8%), and having a strong infrastructure capacity (37.5%) were identified as additional enabling factors. Approximately a third of GAs identified 4 enabling factors that facilitated the recovery process: having trained staff, obtaining federal government support, having the support of key partners and network members, and getting new or improved infrastructure.

Barriers

The top 3 barriers identified for HSOs (Table 5) were: lack/ delay of economic resources and support (36.5%), lack of an integrated emergency response plan (36.5%), and lack of a government plan for an effective, well-coordinated response (34.6%). Lack of effective communications was also the most common reported barrier

https://doi.org/10.1017/dmp.2022.272 Published online by Cambridge University Press

Table 1. Actions taken in preparation for hurricanes Irma and Maria, n (%) by types of organizations

Actions	Services delivery (n = 27)	Emergency, philanthropic, and other support (n = 13)†	Government agencies (n = 6)†	All organizations (n = 46)†
Activate their emergency plans	23 (85.2)	8 (61.5)	5 (83.3)	36 (78.3)
Protect their facilities and equipment	20 (74.1)	5 (38.5)	1 (16.7)	26 (56.5)
Check their level of supplies (e.g., food, water reserves, and power generators, etc.)	19 (70.4)	4 (30.8)	2 (33.3)	25 (54.3)
Staff work rescheduled and flexibility	8 (29.6)	2 (15.4)	–	10 (21.7)
Support staff with their own preparedness plan	5 (18.5)	3 (23.1)	–	8 (17.4)
Ensure company vehicles had gas and were safely parked	2 (7.4)	1 (7.7)	1 (16.7)	4 (8.7)

Note: †Not all organizations reported specific actions taken in preparation for hurricanes Irma and Maria.

Table 2. Main challenges, n (%), by types of organizations within the first 24 to 72 hours after hurricane Maria

Challenges	Services delivery (n = 27)	Emergency, philanthropic, and other support (n = 18)	Government agencies (n = 7)	All organizations (n = 52)
Lack of communication	22 (81.4)	15 (83.3)	6 (85.7)	43 (82.7)
Damages caused to the infrastructure	10 (37.0)	4 (22.2)	4 (57.1)	18 (34.6)
Limited accessibility to critical supplies (e.g., fuel, food)	13 (48.1)	4 (22.2)	–	17 (32.7)
Lack of utility (water and power)	12 (44.4)	–	2 (28.6)	14 (26.9)
Limited road access	8 (29.6)	5 (27.8)	1 (14.3)	14 (26.9)
Lack of generators or limited generator capacity	11 (40.7)	2 (11.1)	–	13 (25.0)
Unable to identify the status and needs of staff, target populations, and/ or providers	4 (14.8)	5 (27.8)	4 (57.1)	13 (25.0)
Mental health impact of staff and target populations	4 (14.8)	4 (22.2)	2 (28.6)	10 (19.2)
High demand of services and support	5 (18.5)	1 (5.6)	–	6 (11.5)
Limited coordination and support from the government	1 (3.7)	3 (16.7)	–	4 (7.6)
Limited transfer of patients and target populations	3 (11.1)	–	1 (14.3)	4 (7.6)

Table 3. Main disaster response services provided to their target population, n (%)

	Services delivery (n = 27)	Emergency, philanthropic, and other support (n = 18)	Government agencies (n = 7)	All organizations (n = 52)
Services to target population				
Provide emergency supplies, food, and water	16 (59.3)	11 (61.1)	2 (28.6)	29 (55.8)
Provide healthcare support (i.e., medical support and pharmacies)	19 (70.4)	2 (11.1)	4 (57.1)	25 (48.1)
Community outreach and assessments	10 (37.0)	10 (55.6)	2 (28.6)	22 (42.3)
Provide medications	8 (29.6)	5 (27.8)	1 (14.3)	14 (26.9)
Setting up triage	6 (22.2)	5 (27.8)	2 (28.6)	13 (25.0)
Donation management and distribution	6 (22.2)	3 (16.7)	1 (14.3)	10 (19.2)
Provide social and mental health support	6 (22.2)	2 (11.1)	1 (14.3)	9 (17.3)
Patients/ communities transfer or evacuation	1 (3.7)	1 (5.6)	3 (42.9)	5 (9.6)
Provide shelters	4 (14.8)	–	1 (14.3)	5 (9.6)
Clean road access	4 (14.8)	–	–	4 (7.7)
Services to human resources				
Provide emergency supplies, food, and water	17 (63.0)	14 (77.8)	1 (14.3)	32 (61.5)
Provide economic or salary support	10 (37.0)	12 (66.7)	–	22 (42.3)
Provide social and mental health support	7 (25.9)	5 (27.8)	4 (57.1)	16 (30.8)
Provide generators and fuel	8 (29.6)	4 (22.2)	1 (14.3)	13 (25.0)
Provide healthcare support (medical and pharmacies)	4 (14.8)	4 (22.2)	3 (42.9)	11 (21.2)
Staff flexibility space, schedule, and hours	4 (14.8)	6 (33.3)	–	10 (19.2)
Identify needs	4 (14.8)	4 (22.2)	1 (14.3)	9 (17.3)
Provide medications	3 (11.1)	2 (11.1)	1 (14.3)	6 (11.5)
Provide shelters	4 (14.8)	–	1 (14.3)	5 (9.6)

https://doi.org/10.1017/dmp.2022.272 Published online by Cambridge University Press

Table 4. Main factors that facilitated the recovery post-hurricane Maria, n (%)

Factor	Services delivery (n = 27)	Emergency, philanthropic, and other support (n = 16) †	Government agencies (n = 6)†	All organizations (n = 49)†
Human resources support and commitment	18 (66.7)	11 (68.8)	1 (16.7)	30 (61.2)
Networks and partnership support	8 (29.6)	7 (43.8)	2 (33.3)	17 (34.7)
Economic support	12 (44.4)	4 (25.0)	1 (16.7)	17 (34.7)
Facilities and equipment improvements	10 (37.0)	4 (25.0)	2 (33.3)	16 (32.7)
Strong infrastructure capacity	6 (22.2)	6 (37.5)	2 (33.3)	14 (28.6)
Anticipated preparedness plan	7 (25.9)	2 (12.5)	1 (16.7)	10 (20.4)
Trained and prepared staff	4 (14.8)	2 (12.5)	2 (33.3)	8 (16.3)
Federal government support	3 (11.1)	1 (6.3)	2 (33.3)	6 (12.2)
Healthy economic/financial capacity	3 (11.1)	2 (12.5)	–	5 (10.2)
Private insurances coverage	2 (7.4)	2 (12.5)	–	4 (8.2)

Note: †Not all organizations reported specific factors that facilitated the recovery post-hurricane Maria.

Table 5. Greatest barriers to the recovery from hurricane Maria, n (%)

Barriers	Services delivery (n = 27)	Emergency, philanthropic, and other support (n = 18)	Government agencies (n = 7)	All organizations (n = 52)
Lack or delay of economic resources/ support	11 (40.7)	4 (22.2)	4 (57.1)	19 (36.5)
Lack of an integrated emergency response plan	12 (44.4)	7 (38.9)	–	19 (36.5)
Lack of government response plan	9 (33.3)	8 (44.4)	1 (14.3)	18 (34.6)
Lack of effective communication	11 (40.7)	4 (22.2)	–	15 (28.8)
Bureaucracy (local and federal)	7 (25.9)	3 (16.7)	3 (42.9)	13 (25.0)
Lack of reliable electrical power	5 (18.5)	3 (16.7)	–	8 (15.4)
Lack of information about availability of resources	2 (7.4)	2 (11.1)	1 (14.3)	5 (9.6)

mentioned by SDOs (40.7%), and EPOS (22.2%). For GAs, local and federal bureaucracy (42.9%) were also frequently mentioned.

Lesson learned from hurricanes

The most frequently reported lesson learned (Table 6) was the need for continued improvement and strengthening of emergency preparedness plans (56.3%); increasing inventory supplies such as food, water, first aid kits, and medications, as well as fuel, etc. (41.7%); and improving internal and external communication systems (37.5%). Other frequently reported learned experiences undertaken by SDOs include improving infrastructure capacity (50.0%) and training their staff as first responders (37.5%). For EPOS, providing education and training (41.2%) were common actions taken for better preparedness. Almost a third (28.5%) of GAs reported sharing experiences and information on areas for improvement and establishing and strengthening relationships with different stakeholders and partners.

Lessons mentioned by interviewers included: '*We purchased a 20-thousand-gallon fuel tank, added a new power generator, we built a water well to expand our water supply capacity, and substituted the water heater fueled by gas for 1 fueled by diesel since it is cheaper and easier to maintain . . .*' Another indicated '*We are generating our own oxygen and renewable energy. Our goal is to become energy independent using the reimbursable funds received from FEMA . . . .*' Another mentioned: '*We implemented a communications redundancy system, purchased additional satellite phones, and improved our internet connectivity . . .*'

As described in Table 7, HSOs expressed needing an integrated/centralized plan to respond to the next emergency (40.9%), followed by government support (22.7%). Additionally, 20.5% of organizations identified having an educated and prepared staff to respond, and having effective communication channels between all parties involved, as important tools for disaster preparedness. Within the government and the private sector, interviewers mentioned the need to have '*clarity on the existing resources available both locally and at the federal level (i.e., resources database); which agencies are responsible for what, and how the communication and coordination process will be handled.*' The planning process should also consider having '*emergency funds, adequate storage space and management of supplies, and a clear command center to identify needs, channel donations, and prevent duplicity and mismanagement.*'

Discussion

Disaster preparedness plans

Although we found that most participating HSOs had preparedness plans prior to the hurricanes, there was limited information about the emergency preparation level (e.g., 4 or 5 of hurricane level). However, all HSOs reported being deficient to respond to

https://doi.org/10.1017/dmp.2022.272 Published online by Cambridge University Press

Table 6. Lessons learned to be better prepared for a future disaster, n (%)

Lesson learned	Services delivery (n = 24)†	Emergency, philanthropic, and other support (n = 17)†	Government agencies (n = 7)	All organizations (n = 48)†
Improve and strengthen emergency/ preparedness plan	13 (54.2)	11 (64.7)	3 (42.8)	27 (56.3)
Increase the inventory of emergency supplies	17 (70.8)	3 (17.6)	–	20 (41.7)
Improve internal and external communication	9 (37.5)	6 (35.3)	3 (42.8)	18 (37.5)
Improve infrastructure capacity	12 (50.0)	2 (28.6)	1 (14.3)	15 (31.3)
Provide education and training	7 (29.2)	7 (41.2)	1 (14.3)	15 (31.3)
Prepare human resources as first responders	9 (37.5)	5 (29.4)	–	14 (29.2)
Establish and strengthen relationships with stakeholders and partners	2 (8.3)	5 (29.4)	2 (28.5)	9 (18.8)
Share experiences and areas for improvement with others	2 (8.3)	4 (23.5)	2 (28.5)	8 (16.7)
Have back-up servers and redundancy	3 (12.5)	1 (5.9)	1 (14.3)	5 (10.4)

Note: †Not all organizations reported specific actions to be better prepared for a future disaster.

Table 7. Needed support to be prepared for a future disaster, n (%)

Support	Services delivery providers (n = 26) †	Emergency, philanthropic, and other support (n = 12)†	Government agencies (n = 6) †	All organizations (n = 44) †
Having access to an integrated and centralized plan to response	10 (38.5)	6 (50.0)	2 (33.3)	18 (40.9)
Government support	7 (26.9)	3 (25.0)	–	10 (22.7)
Have educated and prepared human resource (i.e., staff, volunteers) to respond	7 (26.9)	2 (16.7)	–	9 (20.5)
Effective communication channels	6 (23.1)	2 (16.7)	1 (16.7)	9 (20.5)
Funding/ Economic support	5 (19.2)	3 (25.0)	–	8 (18.2)
Collaborators/ partnership support	4 (15.4)	3 (25.0)	–	7 (15.9)

Note: †Not all organizations reported specific preparedness support for a future disaster.

disasters of the magnitude of hurricane Maria. Deficiencies varied across the different organization types, particularly as financial resources, management systems, and technological sophistication were not equally distributed. Hence, a key lesson learned (as reported by many interviewees), is the importance of having a centralized, multi-level, and multi-organization plan that can leverage resources and information to better prepare for, and respond to future disasters. Researchers also found similar failure patterns in HSOs' crisis preparedness and learning from failures is an important facilitator of preparedness for both this and future emergencies.[23]

Communication strategy

Emergency management officials reported that 95% of cellphone and other communication services such as landlines in both US territories failed after hurricane Maria.[24] Such an unprecedented experience left all HSOs participants with the realization that even among those that had redundancy in their systems, they needed to expand their back-up capacity and improve their infrastructure to ensure their operation's continuity. A recent study in Puerto Rico also found that the disruptions in care and services resulted from damages to health systems, lack of basic services island-wide, and the loss of communication with healthcare teams.[25] However, our study highlights that HSO main organizational improvement was the acquisition of new equipment and technology such as satellite and analog phones, solar radios, solar panels, and power generators to ensure effective and evidence-based strategies for both internal and external communication to be used during and after any disaster.

Infrastructure capacity

Most HSOs activated their emergency plans, protected their facilities/ equipment, and checked their level of supplies in preparation for the hurricanes. These practices have been recommended by organizations that worked with the emergency planning, coordination, education, and management, as well as recovery from disasters such as FEMA, Centers for Disease Control and Prevention, and the Red Cross, among others.[26,27] However, SDOs, immediately after hurricanes, lacked critical supplies and utilities, and GAs faced damages to infrastructure. It was noted that these infrastructure challenges encountered might also be related to the main response services provided by these organizations. For example, we found that most SDOs offered emergency supplies to their target population and GAs were focused in providing healthcare support where a strong infrastructure is needed to attend population needs.

A study in Puerto Rico found a similar experience in terms of the infrastructure impact and capacity after these hurricanes.[25] Researchers discovered that damages to infrastructure and loss of utilities caused many delays and disruptions in the support and services provided to the population after the hurricanes.[25] Overall results revealed that all organizations should continue

https://doi.org/10.1017/dmp.2022.272 Published online by Cambridge University Press

working to build a culture of disaster preparedness and make improvements to their infrastructure capacity as shown in literature.[28,29]

Human resources

The staff of these organizations are at the heart of the preparation, response, and recovery efforts.[30] However, not all interviewed HSOs had a clear plan or delivered critical support to their own employees. A similar challenge was observed in a study that reported limited capability experienced by the human resources and teams responding after hurricane Katrina in 2006.[31]

In our study, HSOs, SDOs, and EPOS provided emergency supplies, food, water, and financial support to their staff; very few GAs provided any of this assistance to their employees. The support GAs prioritized for their staff was healthcare and some mental health services, as many of their employees actively engaged in emergency evacuations due to floods, lost homes, and other accidents. Despite the type of organization, the available literature suggested that emergency response teams should act quickly in the preparation for, and response to any unknown emergency.[32] Based on the experience reported by many participants across all healthcare and social organizations, including GAs, it is critical to adequately plan and support human resources to ensure an effective response and a resilient recovery process as other practices made by relevant organizations.[29,30]

Disaster recovery

The speed and success of recovery can be greatly enhanced by establishing adequate processes and protocols prior to a disaster and ensuring that local and federal authorities allocate and deploy needed resources in a timely, fair, and transparent manner.[33] Recovery in PR and the USVI was slow, and even after almost 5 years, much remains to be done to fully recover.[34] Although the socio-economic and political status of these US territories are not the same as any US State, we observed a pattern of a slow recovery process similar to New Orleans after hurricane Katrina. Over a decade has passed since, and there is still a need to obtain funding for rebuilding, developing reconstruction programs for vulnerable populations, and integrating preparedness and response efforts across the city.[35,36]

Facilitators of the recovery process

Support and commitment of human resources was the main factor that facilitated the post-hurricane recovery for HSOs, SDOs, and EPOS compared to GAs. Additional factors enabling the recovery for SDOs were funding/ economic support and infrastructure improvements compared to networks, partnership support, and strong infrastructure capacity for EPOS. The influx of funding coming from federal grants, health insurance reimbursements, philanthropic donations, and property insurance payments were key to continuing services and to making improvements to HSOs' infrastructure. We also found that infrastructure of SDOs was impacted more compared to EPOS; therefore these factors are critical for organizations' own resilience. Conversely, the network and partnerships are essential components for the recovery operation of EPOS and have been used to build organization resilience. Researchers identified the network and partnerships as key components to build resilience and ensure recovery in the face of multiple disruptions.[37]

Barriers of the recovery process

We found differences in the most frequent barriers to the recovery from hurricane Maria by HSOs. SDOs identified lack of an integrated response plan; EPOS identified lack of government plan/ response; and GAs identified lack/ delay of funding support. They identified bureaucracy, lack of planning, transparency, and limited sense of urgency as recovery barriers. All these barriers are external to each HSO type. However, taken together, they demonstrate the need to improve integration of efforts between sectors as shown by others.[38]

A recent study found similar barriers identified by comparing the experience of SARS/ MERS and COVID-19 in diverse countries, the results need to integrate an effective response network in all countries.[39] Successful post-disaster recovery requires coordination and cooperation at multiple levels as well as horizontally and vertically across layers of administration among government and stakeholders.[40,41] Better partnerships are critical to manage the increased flow of funds, information, and other resources in every aspect of the disaster recovery phase.

Lessons learned

The lessons learned from hurricanes Irma and Maria, according to HSOs, allowed them to identify gaps they had not considered before and made them more resilient. SDOs were primarily increasing the inventory of emergency supplies, food, water, and materials; improving their capacity. EPOS provided education and training to the community and target populations and improved internal and external communication. In addition, GAs improved internal and external communication to have an integrated emergency preparedness plan.

Study results showed that having access to an integrated and centralized plan to respond to the next emergency is needed. Government support, education, human resources that are trained and prepared to respond, and having effective communication channels/ messages between all parties were identified as the best practices to be implemented for future disaster preparedness. Similar lessons learned were identified by researchers studying emergency situations across countries including SARS/MERS and COVID-19.[39,42] Regardless of the country, the findings evidenced the importance of modifying governance structures to establish effective emergency institutions and necessary legislation as critical preparation step for future unknown emergencies.[39] These results demonstrate that organizations are focused on preparedness, advance coordination and planning, and on establishing and strengthening relationships with local and external leaders and communities, despite the multiple internal/ external challenges and gaps that remain for full recovery.[43–45]

Limitations

This study presents some limitations. First, the primary focus was on PR. We only included 3 USVI organizations, which is insufficient to draw conclusions for USVI organizations separately. We selected 1 SDO, EPOS, and GA from the USVI. Themes identified from these interviews were like those reported by the participating HSOs in PR. Also, some HSOs interviewed provided services in both US territories.

Second, interviews were conducted after more than a year of these hurricanes, while others took additional time due to COVID-19 pandemic restrictions and earthquakes that affected PR since January 2021. This could result in recall bias by the

https://doi.org/10.1017/dmp.2022.272 Published online by Cambridge University Press

interviewees due to trauma-induced memory and potential misclassification.[46] This also limited our ability to analyze the data in terms of timing (i.e., actions taken by these organizations within the first 24 to 72 hours, 3-6 months, and 1-year post-hurricane). For all interviews, the interviewer used the semi-structured guide and focused on questions and follow-up questions to reduce this bias. We also explored differences in patterns between organizations interviewed before and after March 2020 (initiation of COVID-19 lockdown in PR), and no differences were found.

Most interviewees were senior-level staff who may have overestimated their organizations' disasters-preparedness and underestimated the impact of the event. However, the organizational structure of most HSOs included in this study have a 'thin' layer of administration, meaning that they are not distanced from frontline-staff by position or physical distance within the organization. This feature may have minimized potential bias from senior-level staff. Although, inclusion of increased numbers of 'frontline-staff' should be done in future studies, as these individuals may indeed have a varying perspective on organizational readiness and event impact.

Further research is recommended to determine the relationship between internal vs. external factors in the preparedness, response, and recovery of HSOs from natural disasters including hurricanes. In addition, research is needed to better understand the differences and interdependencies identified in this study. Investigations should also consider frameworks related to the Crisis and Risk Communication practices to evaluate the best practices applied for communication during an emergency disaster response. Despite these limitations, this study presented multi-domain information about the hurricane preparedness, response, and recovery experience of HSOs in PR and USVI.

Conclusion

Healthcare and social organizations continued working to become more resilient after the experiences lived through during hurricanes Irma/ Maria, and applied several lessons learned to improve future disaster responses. This study suggests that HSOs should promote a culture of preparedness and healthy organizational capacity across all levels to be safe, ensure continuity of operations and services, autonomy, and recover after any disaster. HSOs, also, can learn from other organizations with more disaster experience, and resilience. The government is a critical player to facilitate the preparedness, response, and recovery experiences of HSOs for any disaster. The government should envision an exemplary culture of emergency preparedness by integrating efforts, resources, and sectors at all levels, while actively engaging stakeholders/ players, improving communication channels (internal/ external), and incorporating and disseminating effort, resources, and action plans to all relevant parties. In conclusion, organizations can never be too prepared for any disaster, there are always opportunities to improve their capacity, and response, as well as resilience and networks to minimize the impact in their infrastructure, resources, services, and target populations.

Sources of support. This study was supported by the National Institute on Minority Health and Health Disparities (awards: R21MD013666, U54MD007587, and U54MD007600); and by the National Institutes of General Medical Sciences (award: 1U54GM133807-01A1). We acknowledge the note takers of this study: Radamés Revilla Orellano, Stephanie Seymour, Ibanaliz Santoni, and Erika N Ortiz Chaparro. We also acknowledge Dharma Vazquez Torres PhD, that contributed to the conceptualization of the study and provided input for the recruitment efforts.

Abbreviations. CBOs, Community-Based Organizations; EPOS, Emergency, Philanthropic, and Other Support organizations; FEMA, Federal Emergency Management Agency; FQHC, Federally Qualified Healthcare Centers; GAs, Government Agencies; HSOs: Healthcare and Social Organizations; PR, Puerto Rico; PREPARE, Preparedness to Reduce Exposures and diseases Post hurricanes and Augment Resilience; SDOs, Service Delivery Organizations; UPR, University of Puerto Rico; USVI: US Virgin Islands

References

1. **Cangialosi JP, La BR.** *Tropical Cyclone Report Hurricane Irma. August 30 to September 12, 2017*. 2018. Accessed February 19, 2021. www.nhc.noaa.gov.
2. **Disasters**. Disaster Year in Review 2019. Accessed January 5, 2021. https://cred.be/sites/default/files/CC58.pdf.
3. **Pasch RJ, Pa BR.** *National hurricane center tropical cyclone report: Hurricane Maria (Al152017). September 16-30, 2017*. 2019. www.nhc.noaa.gov.
4. **Corporation R.** Hurricanes Irma and Maria: Impact and aftermath. https://www.rand.org/hsrd/hsoac/projects/puerto-rico-recovery/hurricanes-irma-and-maria.html.
5. **Robles F DK, Fink S, Almukhtar S.** Official toll in Puerto Rico: 64. Actual deaths may be 1052. *The New York Times*. https://www.nytimes.com/interactive/2017/12/08/us/puerto-rico-hurricane-maria-death-toll.html.
6. **Santos-Burgoa C, Sandberg J, Suárez E, *et al.*** Differential and persistent risk of excess mortality from Hurricane Maria in Puerto Rico: a time-series analysis. *Lancet Planet Health*. 2018;2(11):e478-e488. doi: 10.1016/S2542-5196(18)30209-2
7. **Kishore N, Marques D, Mahmud A, *et al.*** Mortality in Puerto Rico after Hurricane Maria. *N Engl J Med*. 2018;379(2):162-170. doi: 10.1056/NEJMsa1803972
8. **George Washington University**. *Ascertainment of the estimated excess mortality from hurricane María in Puerto Rico*. Published August 29, 2018. https://reliefweb.int/report/puerto-rico-united-states-america/ascertainment-estimated-excess-mortality-hurricane-maria
9. **Mattei J, Tamaz M, O'Neill J.** Chronic diseases and associated risk factors among adults in Puerto Rico after hurricane Maria. *JAMA Netw Open*. 2022;5(1):e2139986. doi: 10.1001/jamanetworkopen.2021.39986
10. **Joshipura KJ, Martínez-Lozano M, Ríos-Jiménez P, *et al.*** Preparedness, hurricanes Irma and Maria, and impact on health in Puerto Rico. *Int J Disaster Risk Reduct*. 2022;67:102657. doi: https://doi.org/10.1016/j.ijdrr.2021.102657
11. **Chowdhury MAB, Fiore AJ, Cohen SA, *et al.*** Health impact of hurricanes Irma and Maria on St Thomas and St John, US Virgin Islands, 2017-2018. *Am J Public Health*. 2019;109(12):1725-1732. doi: 10.2105/AJPH.2019.305310
12. **Pasch RJ, Penny AB, Berg R, National Hurricane Center**. *National Hurricane Center Tropical Cyclone Report: hurricane Maria (Al152017)*. September16 -30, 2017. https://www.nhc.noaa.gov/data/tcr/AL152017_Maria.pdf
13. FEMA. America's PrepareAthon! *Prepare your organization for a hurricane Playbook*. https://www.kcercoalition.com/contentassets/7d64be77473d46759d37510a29776036/prepareathonplaybookhurricane.pdf
14. **Parsons M GS, Hastings P, Marshall G, *et al.*** Top- down assessment of disaster resilience: a conceptual framework using coping and adaptive capacities. *Int J Disaster Risk Reduct*. 2016;19:1-11.
15. **Medina C.** La resiliencia y su empleo en las organizaciones. *Gestión y Estrategia*. 2012;1(41):29-39.
16. **Seville E, Brunsdon D, Dantas A, *et al.*** Building organisational resilience: a summary of key research findings. 2006. https://www.academia.edu/12739469/Building_Organisational_Resilience
17. **National Research Council**. *Building community disaster resilience through private-public collaboration*. Washington, DC: The National Academies Press. 2011:142. https://doi.org/10.17226/13028
18. **De Arzola OR.** Emergency preparedness and hurricane Maria: the experience of a regional academic medical center in Southwest Puerto Rico. *J Grad Med Educ*. 2018;10(4):477-480, doi: 10.4300/JGME-D-18-00547.1

19. **Williams M, Moser T.** The art of coding and thematic exploration in qualitative research. *Int Management Rev.* 2019;10(1):45-55.
20. **Hsieh HF, Shannon SE.** Three approaches to qualitative content analysis. *Qualitative Health Research.* 2005;15:1277-1288. doi: 10.1177/1049732305276687
21. **Chongming W.** Bracing for hurricanes: a qualitative analysis of the extent and level of preparedness among older adults. *The Gerontologist.* 2018;58(1):57-67. https://doi.org/10.1093/geront/gnx187
22. **Cho JY, Lee EH.** Reducing confusion about grounded theory and qualitative content analysis: similarities and differences. *The Qualitative Report.* 2014;19(32).
23. **Carmeli A, Schaubroeck J.** Organisational crisis-preparedness: the importance of learning from failures. *LRP.* 2008;41(2):177-196.
24. FEMA. *Hurricane Maria.* 2017. https://www.fema.gov/hurricane-maria
25. **Calo WA, Rivera M, Mendez-Lazaro PA, *et al.*** Disruptions in oncology care confronted by patients with gynecologic cancer following hurricanes Irma and Maria in Puerto Rico. *Cancer Control.* 2022;29:10732748221114691.
26. **Mayer BW, Moss J, Dale K.** Disaster and preparedness: lessons from hurricane Rita. *J Contingencies Crisis Manag.* 2008;16(1):14-23.
27. **Farber DA.** Response and recovery after Maria: lessons for disaster law and policy. *SSRN.* 2018. https://ssrn.com/abstract=3174466
28. **Comfort LK, Waugh WL, Cigler BA.** Emergency management research and practice in public administration: emergence, evolution, expansion and future directions. *Publ Adm Rev.* 2012;72:539-548.
29. **World Health Organization (WHO)**. *A strategic framework for emergency preparedness.* 2017. https://www.who.int/publications/i/item/a-strategic-framework-for-emergency-preparedness
30. FEMA. *FEMA strategic plan: Fiscal years 2008-2013.* 2008. https://www.fema.gov/pdf/about/fy08_fema_sp.pdf
31. **Rodríguez H, Trainor J, Quarantelli EL.** Rising to the challenges of a catastrophe: the emergent and prosocial behavior following hurricane Katrina. *Ann Am Acad Pol Soc Sci.* 2006;604(1):82-101. doi: 10.1177/0002716205284677
32. **van Fenema PC, Romme AGL.** Latent organizing for responding to emergencies: foundations for research. *J Org Design.* 2020;9(1):11. doi: 10.1186/s41469-020-00074
33. FEMA. *National Disaster Recovery Framework*. 2011. https://www.fema.gov/pdf/recoveryframework/ndrf.pdf
34. **Maas Cortés L, Rodriguez-Rivera MZ, James JJ, Cordero JF.** The Caribbean strong summit: building resilience with equity. *Disaster Med Public Health Prep.* 2020;14(1):155-157. doi: 10.1017/dmp.2020.18
35. **Fussell E.** The long term recovery of New Orleans' population after hurricane Katrina. *Am Behav Sci.* 2015;59(10):1231-1245. doi: 10.1177/0002764215591181
36. **Servick K.** More than 12 years after Hurricane Katrina, scientists are learn ing what makes some survivors more resilient than others. *Science Magazine.* 2018. https://www.sciencemag.org/news/2018/02/more-12-years-after-hurricane-katrina-scientists-are-learning-what-makes-some-survivors
37. **Sahebjamnia N, Torabi SA, Mansouri SA.** Building organizational resilience in the face of multiple disruptions. *Int J Prod Econ.* 2018;197:63-83. https://doi.org/10.1016/j.ijpe.2017.12.009
38. **Crichton MT, Ramsay CG, Kelly T.** Enhancing organizational resilience through emergency planning: learnings from cross-sectoral lessons. *J Contingencies Crisis Manag.* 2009;17(1):24-37. https://doi.org/10.1111/j.1468-5973.2009.00556.x
39. **Feitelson E, Plaut P, Salzberger E, *et al.*** Learning from others' disasters? a comparative study of SARS/MERS and COVID-19 responses in five polities. *Int J Disaster Risk Reduct.* 2022;74:102913.
40. **Lechner S, Jacometti J, McBean G, Mitchison N.** Resilience in a complex world – Avoiding cross-sector collapse. *Int J Disaster Risk Reduct.* 2016;19:84-91. doi:https://doi.org/10.1016/j.ijdrr.2016.08.006
41. **Vallance S.** Early disaster recovery: a guide for communities. *Australas J Disaster Trauma Stud.* 2011;2:19-25.
42. **Hay K, Pascoe KM.** Engaging social workers in disaster management: case studies from New Zealand. *Int J Disaster Risk Reduct.* 2022;74:102941.
43. **US Department of Labor**. *Hurricane preparedness and response*. https://www.osha.gov/hurricane/preparedness
44. **Liu W, Lai C-H, Xu W.** Tweeting about emergency: a semantic network analysis of government organizations' social media messaging during hurricane Harvey. *Public Relat Rev.* 2018;44(5):807-819.
45. **Hallegatte S, Vogt-Schilb A, Rozenberg J, *et al.*** From poverty to disaster and back: a review of the literature. *Econ Disasters Clim Change.* 2020;4:223-247. https://doi.org/10.1007/s41885-020-00060-5
46. **Moreno-Serra R, Anaya-Montes M, León-Giraldo S, *et al.*** Addressing recall bias in (post) conflict data collection and analysis: lessons from a large-scale health survey in Colombia. *Confl Health.* 2022;16:14. https://doi.org/10.1186/s13031-022-00446-0

https://doi.org/10.1017/dmp.2022.272 Published online by Cambridge University Press