HHS Public Access

Author manuscript

J Emerg Manag. Author manuscript; available in PMC 2024 June 24.

Published in final edited form as:

J Emerg Manag. 2022 ; 19(8): 63–77. doi:10.5055/jem.0631.

Public health branch incident management and support as part of the Federal Government response during the emergency phase of Hurricanes Irma and Maria in Puerto Rico and the US Virgin Islands

Miguel Angel Cruz, PhD,
National Center for Environmental Health, (Now) Agency for Toxic Substances and Disease Registry, Centers for Disease Control and Prevention, Atlanta, Georgia.

Luis O. Rivera-González, PhD,
Toxicologist, Region 2, Office of Community Health and Hazard Assessment (OCHHA); Agency for Toxic Substances and Disease Registry (ATSDR); Centers for Disease Control and Prevention (CDC), New York, New York.

Elizabeth Irvin-Barnwell, PhD,
Agency for Toxic Substances and Disease Registry, Centers for Disease Control and Prevention, Atlanta, Georgia.

Jessica Cabrera-Marquez, PhD,
Public Health Emergency Preparedness and Response Program, Puerto Rico Department of Health, San Juan, Puerto Rico.

Esther Ellis, PhD,
Epidemiology and Disease Reporting Program, Territorial Public Health Laboratory, Virgin Islands Department of Health, St. Croix, US Virgin Islands.

Brett Ellis, PhD,
Territorial Public Health Laboratory, Virgin Islands Department of Health, St. Croix, US Virgin Islands.

Benjamin Qi, PhD,
US Army Medical Research and Development Command, Ft. Detrick, Maryland.

Christopher Maniglier-Poulet, MS,
Agency for Toxic Substances and Disease Registry, Centers for Disease Control and Prevention, Atlanta, Georgia.

Justin Andrew Gerding, DHA,
National Center for Environmental Health, Centers for Disease Control and Prevention, Atlanta, Georgia.

Alice Shumate, PhD,

Disclaimer: The findings and conclusions in this article are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention. The authors have no conflicts of interest.

National Institute of Occupational Safety and Health, Centers for Disease Control and Prevention, Cincinnati, Ohio.

Ashley Andujar, MHSA,
National Center for Emerging & Zoonotic Infectious Diseases, Atlanta, Georgia.

Jonathan Yoder, MPH,
National Center for Emerging & Zoonotic Infectious Diseases, Atlanta, Georgia.

Joseph Laco, MS,
National Center for Environmental Health, Centers for Disease Control and Prevention, Atlanta, Georgia.

Alberto Santana, MS,
National Center for Injury Prevention and Control, Centers for Disease Control and Prevention, Atlanta, Georgia.

Tesfaye Bayleyegn, MD,
National Center for Environmental Health, Centers for Disease Control and Prevention, Atlanta, Georgia.

Carolina Luna-Pinto, MPH,
National Center for Emerging & Zoonotic Infectious Diseases, Centers for Disease Control and Prevention.

Luis Orlando Rodriguez, MS,
National Center for Environmental Health, Centers for Disease Control and Prevention, Atlanta, Georgia.

Joseph Roth, MPH,
Center for Preparedness and Response, Centers for Disease Control and Prevention, Atlanta, Georgia.

John Bermingham, MS,
Center for Preparedness and Response, Centers for Disease Control and Prevention, Atlanta, Georgia.

Renée H. Funk, DVM,
Agency for Toxic Substances and Disease Registry, Centers for Disease Control and Prevention, Atlanta, Georgia.

Murad Raheem, BS
Office of the Assistant Secretary for Preparedness and Response, Department of Health and Humans Services, New York City, New York.

Abstract

On September 6 and 20, 2017, Hurricanes Irma and Maria made landfall as major hurricanes in the US Caribbean Territories of the Virgin Islands and Puerto Rico with devastating effects. As part of the initial response, a public health team (PHT) was initially deployed as part of the US Department of Health and Human Services Incident Response Coordination Team. As a result of increased demands for additional expertise and resources, a public health branch (PHB)

was established for coordinating a broad spectrum of public health response activities in support of the affected territories. This paper describes the conceptual framework for organizing these activities; summarizes some key public health activities and roles; outlines partner support and coordination with key agencies; and defines best practices and areas for improvement in disaster future operations.

Keywords

public health; emergency management; natural disasters; environmental health; disaster assessments

INTRODUCTION

Major natural disasters, such as hurricanes, can cause widespread catastrophic damage that devastates communities, threatening the wellbeing of affected populations and their living environment.[1] This damage can affect critical infrastructure, including health care facilities (HCF), public health facilities, and power and water systems. In addition, damage to transportation and communication systems may limit access to remote and isolated communities. Disasters also affect vulnerable populations, such as individuals who are chronically ill or have disabilities and special needs, and the socioeconomically disadvantaged.[2,3] In the aftermath of any disaster, public health agencies must coordinate and respond early to protect the health not only of affected citizens, but also of disaster responders.[4] Their response supports partners in the affected areas several ways. They can provide remote technical consultation and assistance, support continuity of essential services, and deploy needed resources and equipment, as well as qualified individuals, to the affected areas to augment or support response activities. In addition, public health professionals bring expertise and tools to assist with evaluating and characterizing disaster impacts in communities.[5]

The portfolio of public health resources for disasters includes tools and methods for collecting health surveillance data, executing risk and needs assessments, communicating health risks, and controlling misinformation. Public health teams (PHTs) can also assist with vector control; monitor common environmental hazards associated with food, water, and air contamination; ensure safe handling of large amounts of waste and hazardous materials; and assess health hazards in communities, public health and medical buildings, and public facilities such as schools and shelters.[3,6–12] Public health disaster teams provide valuable information necessary for situational awareness, resource requests, and actions necessary to bring lifesaving or critical systems to protect affected communities.[13,14]

Internal and external coordination and execution of these tasks require clear organization and command structure. Establishing and being part of an incident management system (IMS) is an important first task. An IMS helps assemble and coordinate resources from all jurisdictional levels in disasters. In the Irma and Maria response, the IMS structure was fundamental in managing a variety of specialty teams and activities from several agencies. For all disaster responses, the primary model for supporting and coordinating a jurisdictional response area is outlined in the National Response Framework (NRF).[4] The

NRF describes four fundamental response priorities: save lives, protect property, protect the environment, and provide basic human needs. Within the NRF, the response capabilities of federal agencies are organized under the Emergency Services Function (ESF) construct. The Department of Health and Human Services (HHS) leads the response for Public Health and Medical Services activities under Emergency Support Function #8 (ESF-8) and provides support to other ESF activities such as ESF-6 Mass Care Services and ESF-10 Oil and Hazardous Materials Response.[4] This approach provides a framework for coordinating a variety of specialty teams across several agencies.

In developing this manuscript, the authors reviewed hurricane preparedness and response documents such as situation reports, incident action plans, organizational charts, and after-action reports to summarize the wide range of activities conducted by the branch PHTs. This report summarizes steps taken to establish the public health core teams and an organizational structure; describes federally supported public health emergency response activities; and highlights cross-agency coordination efforts to support the public health needs of the residents in the US Caribbean territories after Hurricanes Irma and Maria.

HURRICANES IRMA AND MARIA LANDFALLS AND INITIALIZATION OF PUBLIC HEALTH RESPONSE ACTIVITIES

The Atlantic hurricane season begins June 1 and ends November 30. During this period, US coastal states and Caribbean territories prepare for major hurricanes. Storm intensity can range from a tropical storm to a major hurricane capable of bringing destructive winds, storm surge, heavy rainfall, and landslides.[15] During September 2017, Hurricanes Irma and Maria devastated Puerto Rico (PR) and the US Virgin Islands (USVI) in the Caribbean. As a category five storm with winds as high as 185 miles per hour, Hurricane Irma devastated much of the USVI and brushed the island of PR causing severe damages, floods, and widespread loss of power.[16]

Two weeks later, Hurricane Maria landed in the USVI and PR as a category four storm, resulting in additional impacts and damages in the already ravaged territories.[17] The combined impact of these two storms caused a collapse of the entire power grid and left many residents with damaged homes. In many cases, it also eliminated access to clean water and basic communications, such as phone or internet, and shut down businesses and health care systems. President of the United States, Donald J. Trump, approved Major Disaster Declarations for the Caribbean Territories for the USVI on September 7, 2017, and for PR three days later.[18,19]

HHS followed by issuing a declaration of public health emergency for the USVI and PR, allowing for the release of additional funding and resources necessary to support the territorial response.[20,21] On September 10, 2017, HHS deployed an Incident Response Coordination Team (IRCT) (recently rebranded as “Incident Management Team” (IMT)) to PR and USVI to initiate Hurricane Irma ESF-8 Public Health and Medical Services operations in both US territories. The IRCT uses the Incident Command System (ICS) prioritizing and organizing public health and medical services support and establishing the initial public health resources in the management structure.[22] The IRCT also represents

the ESF-8 at the FEMA Joint Field Office or JFO. During large event responses requiring coordination with senior government officials, a designated Senior Health Official (SHO) representing HHS leadership accompanied the team. PR served as the initial base for arrival and staging of teams and logistics resources of the IRCT and for deploying resources to the USVI. Often disaster conditions, limited transportation resources, lodging availability in affected areas require a gradual arrival of emergency resources to help manage them safely and efficiently. While resources were coordinated and deployed, IRCT senior leaders in the islands worked directly with the local public health and medical officials in identifying areas of immediate ESF-8 support.

Embedded within the IRCT was a small, multidisciplinary PHT with expertise in disaster epidemiology (epi), environmental health and hazardous materials, water system infrastructure assessment, public information, and incident management. The PHT initial task consisted of carrying out the initial disaster assessment and established the initial coordination with their public health counterparts in the affected US territories. After evaluating the initial impacts of Hurricane Irma with the Puerto Rico Department of Health (PRDOH), the PHT traveled to the USVI to support the USVI Department of Health (VIDOH) in assessing needs. After hurricane Irma landfall, VIDOH initial needs consisted of public health resources to support shelter surveillance and disaster shelter assessments, augment clinical support staff and surveillance, conduct vector control assessments, and implement vector control measures. After Hurricane Maria landfall, they also requested support for incident management team operations (Emergency Operations Center (EOC), operations, and logistics), and environmental health monitoring. Initial observations revealed great impacts to medical and public health infrastructure and services available in the USVI.

The team’s work in the USVI lasted only a few days as Hurricane Maria, then forecasted to be a category four or five storm, presented a new regional threat with potential to cause further damage to already-affected areas.[17] As a result, FEMA safety officials requested that response teams on the USVI, including the PHT, return to PR ahead of the storm to shelter in place. After Hurricane Maria made landfall in PR, HHS and the PRDOH identified additional needs for public health and medical assistance, increasing the requirements for staffing, public health experts, equipment, and other material resources. With the arrival of additional public health staff, the small PHT morphed into a public health branch (PHB) to adequately manage the surge in public health staff and resources deployed in support of the territorial responses.

The incident PHB management structure established followed ICS concepts, principles, and accountability requirements (Figure 1). Most seasoned responders are familiar with this system’s flexibility and corresponding modular ability to organize teams and their public health functions. The IRCT provided logistical or administrative support to the PHB to carry out mission assignments. Planning and operations personnel embedded in the PHB integrated public health activities with the overall IRCT plans and operation objectives, while the IRCT Plans Section served as the final approval authority for all PHB field activities. Several operational divisions of HHS contributed specialists with expertise in emergency management, epi/surveillance, health communication, environmental health, occupational health, and infectious diseases. The federal public health staff also included

staff with subspecialties in hazardous materials, food and water systems, vector control, safety, immunizations, and laboratory sciences.

ENVIRONMENTAL HEALTH ACTIVITIES

Hurricane Maria left both PR and USVI with a range of complex environmental health issues and concerns, which were, and still are being addressed by the joint efforts of various agencies and organizations. The complexity of the environmental challenges required effective coordination between the PHB, PRDOH, VIDOH, and other territorial and federal agencies involved in the response. The majority of the PHB consisted of environmental health specialists and engineers from various HHS operational divisions and national partner organizations with expertise in several areas, including water systems assessment. Using water testing equipment, PHB teams assessed the status of water systems in priority facilities. They began by collecting water samples to test for chlorine residual and coliform bacteria from the main water storage systems supplying the San Juan Medical Center area. This medical complex consists of several specialty hospitals and centers and the only trauma center serving PR and the neighboring Caribbean islands. Staff from the PHB also assessed military facility water systems, assisted the IRCT safety team with evaluating responder billeting, and joined the PRDOH in assessing the largest disaster shelter near San Juan. Damaged pumps and fuel shortages hindered access to potable water for drinking and daily chores for most of the island. PR's Aqueduct and Sewer Authority (PRASA) and non-PRASA pumps, stations, and systems in very remote parts of the island were also inoperable. As a platform for coordination, the PHB joined FEMA drinking water discussions, leading to stakeholder agencies and organizations establishing a water task force. Team members participated in briefings held by the water sector, co-led by the US Environmental Protection Agency (EPA) and PRDOH.[27]

While efforts were underway to evaluate and safely bring community water systems back online, territorial and federal public health stakeholders also worked together with volunteer agencies and donors to provide or increase access to safe water. They launched a massive logistical effort to distribute potable bottled water via ground and rotary aircraft to remote areas. Other efforts included using Department of Defense (DOD) mobile water purification and treatment units, delivering water storage tanks to key access points for community members, and distributing water purification tablets in very remote areas where the use of untreated water was reported. The execution of these strategies successfully demonstrated the effectiveness of working in communication efforts with a variety of partners. For example, environmental health team members worked with other agency counterparts on the communications team to prepare bilingual, culturally appropriate messaging and materials describing how to use water purification filters and tablets. Spanish-language media campaigns were launched to clarify issues with hyperchlorination of drinking water.

In the USVI, Hurricane Irma initially devastated St. Thomas and the small island of St. John; then, Hurricane Maria compounded the impacts to buildings and services such as health department and healthcare facilities and schools on the first two islands and the island of St. Croix. The VIDOH buildings suffered extensive water and wind damage. Debris, power lines, and solid waste littered most of the roads, public buildings, and schools, creating

environmental hazards. Residents had no access to power or safe water. Communication system towers were destroyed, limiting phone and radio communication to and from the islands. In the USVI, the reduced environmental health staff and severe post-storm damage limited VIDOH's ability to assess and respond to environmental health challenges. The VIDOH and PHT recognized that environmental health need assessments would be crucial in identifying the most urgent issues for community members, particularly for those with pre-existing health conditions. As a result, assessments of access to clean water, safe food, and vector control immediately became public health priorities.

The homes of many public health, medical workforce, and health department employees in PR were destroyed or damaged in the storm. VIDOH buildings on the islands of St. Croix and St. Thomas experienced ongoing rainwater intrusion and worsening mold issues. The only hospital on St. Thomas sustained catastrophic damages, resulting in severe mold and hazardous materials contamination and concerns regarding potential radiation contamination concerns. Other facilities of concern were schools, day care centers, restaurants, food distribution centers, and grocery stores.

The VIDOH PHT conducted environmental health needs assessments focused on providing access to safe water, ensuring appropriate food handling practices at food service facilities, and monitoring proper temperature at grocery stores and food stations. Health surveillance at disaster shelters monitored and identified harmful conditions, unusual injuries, or potential outbreaks of communicable disease. Other preventive activities included health communication efforts focusing initially on water decontamination, household cistern remediation, safe mold clean up, generator use, and food handling and disposal.

Following disasters, monitoring and disease control services, may be required. Including this information in environmental assessments and surveys helps identify and evaluate vector-borne disease risk factors.[3,23] Federal assistance for vector surveillance and control is available from FEMA, with recommendations from the Centers for Disease Control and Prevention (CDC) after certain risk-evaluation criteria are met. The issuance of a post-disaster vector control recommendation enables jurisdictions to work with authorities, including DOD, when more enhanced prevention and control strategies are necessary.[24,25]

An increased mosquito population following a hurricane or flood is common phenomenon, so the PRDOH made vector control a priority in the Hurricane Maria response. A major concern was the presence of *Aedes aegypti*, a mosquito species endemic to the Caribbean region and capable of transmitting dengue, zika, and chikungunya. Well-documented outbreaks of these diseases in PR and the USVI added to the sense of urgency for increased monitoring activities.[25,26] To assist with these efforts, the PHB requested and deployed vector control specialists to assist the PRDOH and VIDOH. Teams conducted rapid assessments to evaluate the vector control programs and met with senior-level emergency management, government officials, and industry leaders to discuss vector control services and prevention of vector-borne diseases. The impacts of both hurricanes affected mosquito control program facilities. Several regional offices and warehouses of the PRDOH mosquito control program reported structural damage and loss including buildings, equipment, vehicles, and supplies. Members of the team worked directly with organizations to document

damage and loss and use the information to request funding from FEMA under various public assistance programs for mitigating structures and performing temporary or permanent repairs.

PHB staff with expertise in vector control worked with the Joint Information Center (JIC) and with the PHB communication team to create messaging about the importance of the use of mosquito personal protection measures and to enlist the public's assistance in eliminating potential breeding sites for mosquitoes. The team also led discussions on the importance of debris cleaning, water draining, and public education. Additionally, some types of vector control methods were a concern. For example, an estimated 60–70 percent of USVI residents used rainwater collection systems in their homes, and aerial or truck-based spraying could contaminate the water.

Even before the storms, the capacity for vector surveillance and control was limited. The VIDOH worked with neighboring Caribbean partners who provided in-kind support for vector control. However, limited data on mosquito surveillance information affected the immediate evaluation and assessments of vectors. For example, FEMA requires submission of vector activity data along with requests for vector-control assistance, but baseline or background data were not immediately available. The PRDOH, DOD, the PR Vector Control Unit, and staff from the CDC Dengue Branch located in PR conducted mosquito trapping and surveillance and mapped sites that showed increased mosquito activity. Initial mosquito surveillance efforts took place in large urban areas in San Juan, Mayaguez, and Ponce; later, additional surveillance sites were established in other municipalities. Despite general concerns, public health partners determined the potential for vector-related issues was low, based on the data collected from those sentinel sites.

DISEASE SURVEILLANCE, PREVENTION, AND CONTROL

Survivors in post-disaster conditions may face ongoing health risks from poor sanitation and lack of access to safe food or water. The loss of home protective barriers, increased human-animal interaction, and other health challenges. Integrating multijurisdictional public health expertise into disaster response can help mediate these concerns and monitor associated risks. Although, PRDOH was able to maintain parts of the local surveillance system in operation, reporting lags due to damages to communication systems and IT and damage to the public health laboratory limited their ability to confirm infectious diseases quickly. Impacts to laboratory equipment and testing equipment required outside assistance to help confirm diagnoses.

To address these post-disaster challenges, the PHB Epi/Surveillance Team implemented enhanced surveillance at several Veterans Administration (VA) and DOD facilities. The PRDOH and PRB worked with the VA to collect individual and aggregate-level data for surveillance purposes. Epi/Surveillance team personnel conducted individual level syndromic surveillance by abstracting data from medical records at three VA locations. Additionally, the team collaborated with DOD to collect aggregate-level surveillance data from DOD temporary field medical treatment stations. Data from DOD, and VA hospitals, clinics have been used in syndromic surveillance since the 2001 terrorist attacks.

In PR, Disaster Medical Assistance Teams (DMAT) operated medical treatment sites/ federal medical stations (FMSs) locations around the island, which reported data into the Electronic Surveillance System for the Early Notification of Community-based Epidemics (ESSENCE).[27,28]

DOD medical treatment throughout the island also included operations in temporary sites and the US Navy Ship Comfort. These facilities submitted daily aggregate syndromic surveillance reports to the PHB epi/surveillance team, including counts of infectious disease syndromes, acute mental health symptoms, acute injury conditions, and "other" illnesses. For their daily surveillance reports, the PHB pulled illness data from ESSENCE, including fever, gastrointestinal illness, influenza-like illness, injuries, and respiratory syndromes. The PHB had a limited role in surveillance of infectious diseases and other health conditions in nonfederal sites, as many of these activities were under the purview of the territorial health agencies; this information was not accessible, and therefore, not included in the PHB surveillance report.

These data collection efforts demonstrate that public health surveillance, in collaboration with all public health and medical partners in theater, is critical in monitoring potential threats. Although PHB public health surveillance efforts were limited, access to the PRDOH and VIDOH epidemiology/surveillance staff provided a reasonable view of the most critical health issues occurring at sentinel sites. PHB met often with PRDOH epidemiologists to assess and discuss any surveillance support needs.

In the USVI, residents were concerned about emerging public health issues caused by power loss, poor living conditions, eg, homes with no roofs, continued rain and standing water, and infrastructure damage to transportation, potable water, and healthcare. During the aftermath of these storms, the VIDOH staff collaborated with shelter volunteers to implement a surveillance system using the existing Red Cross Aggregate Morbidity (Tally) form to tally daily client visits from each shelter. Data collected between September and October 2017 from the three shelters on St. Croix and two on St. Thomas provided the VIDOH with one of the only sources of evidence-based, near real-time public health data available during the response and helped guide response and recovery efforts to protect community health.

Other health concerns in the affected territories included the re-emergence of endemic diseases, such as leptospirosis and rabies. Destruction of physical barriers between residents and the environment, lack of potable water, and large amounts of debris created concerns about potential outbreaks of waterborne and epizootic disease. A higher risk of exposure to leptospirosis was an immediate concern because of increased human contact with floodwaters, unsafe water consumption, and the presence of rodents in damaged homes. During past hurricanes in the island, the PRDOH documented considerable increases in leptospirosis cases.[29] As a result, authorities increased prevention education for the public and physician education for managing suspected cases.

Health concerns about potential for increased risk of exposure to rabies, prompted requests for procuring additional animal and human rabies vaccinations from the US Department of Agriculture National Veterinary Stockpile.[30] In PR, rabies is endemic in the mongoose

population, and both human and animal rabies cases are well documented.[31,32] Loss of structural protection at homes, and disruption of animal habitat after a storm may increase human-animal contact. In PR, the PHB received also multiple reports from field teams about stray cats and dogs coming in close contact with shelter occupants in some facilities. The PHB helped secure additional vaccines until a steady resupply was established. In the USVI, the discovery and subsequent confirmation of two diseases, leptospirosis, and mellidiosis, led to concerns regarding exposure to contaminated or untreated water. These included public health surveillance, vector control, and information distribution to help citizens avoid additional health risks.

HEALTHCARE FACILITY AND COMMUNITY POST-IMPACT NEEDS ASSESSMENTS

Assessments of healthcare facilities are an essential task in any post-disaster setting. The World Health Organization encourages adopting initiatives such as the “Safe Hospitals” framework to ensure hospitals and health facilities are safe in preparation and or following disasters and to maintain continuity of essential operations for the local population and responders who may deploy to the response location.[33]

Health care facilities (HCFs) routinely serve those affected by injury, illness, and chronic health conditions, such as kidney failure. However, after disasters, in addition to providing medical care to affected communities, HCFs take on enhanced roles, including comforting victims and serving as a distribution and resupply point for medicine and oxygen. Disruptions to healthcare services can result in increased mortality as well as exacerbated illness and chronic disease conditions. Loss of hospital care can mean loss of lifesaving medications and treatment for people with chronic conditions, such as diabetes and hypertension, and for those requiring dialysis and respiratory or mental health services. Long delays in electrical service restoration quickly render medications and vaccines unusable, endanger those at risk of overheating without air-conditioning, and damage facility systems sensitive to rising temperatures such as operating suites, negative pressure rooms, air conditioning, and septic systems.[34] As a result, the PRDOH and HHS/IRCT made HCF evaluation a primary PHB mission.[35]

After the hurricanes, the PHB was requested by the IRCT leadership to support local public health authorities by conducting post-impact assessments in PR and USVI HCFs. In September 2017, approximately 66 hospitals and 215 healthcare centers in PR required assessment. In the USVI, the task involved assessing two hospitals, one in St. Thomas and one in St. Croix. Several HCF assessment teams, consisting of environmental health specialists, sanitarians, and engineers, undertook this large operation in PR and the USVI. Because of safety issues, curfews, and austere post-disaster conditions, the teams were initially allowed to conduct field activities only when escorted by law enforcement. They had high frequency radios and satellite phones; however, outside the metropolitan area of San Juan, most cellular and even satellite phone service was unavailable. Damage to roads and bridges required numerous detours, making car travel dangerous and time-consuming and causing delays in collecting this critical information. The DOD and Department of

Homeland Security (DHS) made rotary wing aircraft, such as helicopters and Osprey, available as alternate means of transportation for field teams.

To ensure internal consistency of all HCF assessments and data collection, PHB staff trained all field team members in using the assessment tool and methods and led the facility assessment process. Teams were briefed twice daily, prior to departure and upon returning to the PHB, which was located at the FEMA Joint Field Operations (JFO). Because this task was urgent, teams initially used an existing paper version of a hospital assessment tool and a modified version for assessing smaller facilities such as healthcare centers, which did not have a hospital's wider scope of services and complex unit areas. The initial needs assessment tool documented facility structural damages, operational status of various hospital service units, and utilities or power generation when applicable. Also, the tool identified other immediate resource and supply shortfalls including medical supplies, personal protective equipment, medications, oxygen, fuel, staffing, and support for facilities requiring medical evacuation.

As the response progressed, the HCF tool was modified to accommodate specific information needs of response agencies providing support to these facilities. Other information collected included patient census, beds lost because of hurricane-related damage, morgue spaces available, and number of bodies held in the morgue. The information collected was used to validate requests for supplies, equipment, and other necessary resources to operate the facilities and monitor issues like morgue capacity. Overall, the team completed assessments of most HCFs in PR: 64 hospitals (97 percent) and 187 HCFs (85 percent). The final part of the operation included entering the data and providing a brief report of critical information and immediate needs to the PRDOH, FEMA, and HHS. Data capture, analysis, and reporting improved significantly later in the response, expedited by the use of an app-based survey tool that allowed for faster database population and data visualization via dashboards. The teams also reported safety, logistical, and communication challenges when traveling around the island, including long lines for refueling, lack of reliable physical location information, and lack of Spanish-speaking public health staff.

The PHB also assessed FMS sites and conducted preoccupancy assessments of potential sites. FMS sites are temporary medical facilities capable of caring for 50–250 people who require a safe location and suitable wrap-around services such as power, water, and sewage. They provided temporary shelter for evacuees from nursing home and long-term care facilities who required basic levels of healthcare and monitoring.[36] After two major hurricanes, many potential FMS locations were not fit for human occupancy. The comprehensive safety and operational assessments that PHT conducted were critical for ensuring FMS facilities could safely house patients and caregivers.

During this response, the PHB was invited to participate in interagency discussions identifying needs in isolated communities (ICOS) in the mountains of PR left inaccessible by the storms. DHS was able to identify those at-risk communities during search and rescue operations and aerial surveys. The PHB listened to the concerns and proposed to assist the group by deploying teams to assess and document needs in those communities. The

CDC has developed a disaster assessment method known as Community Assessment for Public Health Emergency Response or CASPER for disaster situations. This method is designed to provide timely, inexpensive, and representative household-based information about community needs.[11] The PHB adopted a CASPER-like tool and interview approach to gather information from households in the ICOS. Logistics and transportation were coordinated by DHS and DOD. They facilitated access to dedicated aircraft to transport members of assessment PHB teams to these remote areas. The team members traveled mostly by foot to interview residents to complete de assessments. The assessment tool used by the PHB to record household interviews included questions about illnesses/deaths, resource and commodity needs, and access to information about health and social services. Upon return, teams provided a daily summary of key findings to both DHS and IRCT for both planning purposes and delivery of any needed resources and supplies. The ICOS team also recommended conducting formal CASPERs in more affected communities. The information generated by CASPERs can be used to initiate public health action; facilitate disaster planning, response, and monitoring recovery activities; and assess new, changing, or emerging needs during the disaster recovery period.

In the USVI, the VIDOH conducted two CASPERs in November 2017 to assess USVI residents' hurricane experiences during Irma and Maria and the public health impacts in communities before, during, and after the hurricanes. The information collected by the CASPERs assisted the VIDOH, the Virgin Island Territorial Emergency Management Agency, and other partners in developing a long-term hurricane recovery plan. CASPER baseline information helped monitor ongoing recovery efforts following the storms, and the VIDOH conducted a follow-up recovery CASPER in February 2018.

HEALTH AND RISK COMMUNICATIONS

HHS supported deploying CDC health communication specialist teams to PR and the USVI to provide direct support to the public health departments. During large-scale incidents, response agencies may assign communication and media staff to a JIC to assist with coordinating and creating cohesive key preventive messages and information. These specialists worked alongside PRDOH, HHS media specialists, and the FEMA JIC at the San Juan Joint Field Office to develop educational materials and to disseminate clear, timely, science-based, post-hurricane messages on health promotion, and disease prevention. The health communications team created a communication plan with multichannel strategies, tactics, and tools that included printed materials, community outreach events, print and radio interviews, video/photography, and social media campaigns. The assessment of health information needs as a result of the environmental effects of Hurricanes Irma and Maria identified gaps regarding risk- and hazard-specific information. The PHB worked with the JIC or directly with PRDOH Office of Communications in producing health communications materials in post-event safety, infectious disease prevention, water and food safety, and exposures to air pollutants, including carbon monoxide hazards.

As the response issues evolved, the team also created, printed, and assembled packets of CDC and PRDOH cobranded health education fact sheets on food and water safety, leptospirosis, mold, and mental health. All materials were translated and reviewed for Puerto

Rican Spanish and cultural appropriateness. During 30 community outreach events held throughout the island, the PHB communication team distributed over 1.5 million fact sheets in shelters, disaster recovery centers, military distribution centers, clinics, hospitals, schools, and homes in rural and isolated communities.

The communications team in PR also assisted with streamlining the processes for the PRDOH, FEMA, and CDC scientific and communication experts to vet and approve public health materials and key messages. For example, public affairs and FEMA JIC officers worked together creating public health messages and health education materials highlighting risks associated with disasters, eg, carbon monoxide. In addition, PHB health communication staff assisted the PRDOH in developing statements addressing rumors about cholera outbreaks in communities. The team worked with PRDOH and CDC cholera experts to construct the appropriate messages and factual statements to control the misinformation and reassure the public. After a few HCFs reported suspected cases of leptospirosis, the team helped develop a strategic communications plan for health education; coordinated clinician outreach presentations and calls; arranged media interviews with local health and CDC experts; and produced fact sheets, posters, public service announcements, and social media messages.

Despite the communication infrastructure challenges in PR, the team successfully evaluated, and adapted their communication strategies based on feedback and information gathered, mostly in person, about public health issues occurring in the impacted communities. As a result, residents began receiving timely and critical public health information, allowing them to make informed decisions to protect themselves and their families. The team strategies relied heavily on distribution of printed materials and direct community-based health promotion and outreach, which effectively reached at-risk individuals and communities with the right messaging.

The team also identified social media groups formed by Puerto Ricans in the US mainland (known as “la diaspora”) who relied on technology to connect with family and help people on the island. These outlets could target health prevention messages and post relevant digital messages on the Facebook group platforms that could be relayed to people in PR by word of mouth. Leveraging response efforts with the PRDOH, FEMA, Red Cross, and other key partners proved to be an effective strategy for cohesive messaging. Finally, assembling a team of experienced, flexible, and culturally sensitive communicators, many of whom were natives of PR, was critical in implementing public health strategies, especially during the initial chaos that so often follows a disaster.

RESTORATION OF PUBLIC HEALTH SERVICES AND SYSTEMS

Restoring preventive services and systems after any large disaster begins in the response phase and continues through recovery. The backbone of any public health disaster response is the ability to quickly determine which issues have the greatest potential to affect communities and emergency responders. An interruption in key public health systems and preventive services, even for a short period in a nondisaster situation, can threaten public health. After these hurricanes, those systems were left severely degraded for months. An

increased risk of disease could result from delayed or absent systems such as routine and seasonal immunizations, treatment and diagnosis of chronic and infectious conditions, food and water quality monitoring, and laboratory testing. During the aftermath of Hurricane Irma and Hurricane Maria, the PHB coordinated the deployment of assessment teams to evaluate operational capacity and damage to public health facilities and established a framework for transitioning information about those impacts to the recovery phase.

The first step was establishing a restoration of services team as part of the PHB, which included members of several federal agencies such as FEMA and several HHS Operating Divisions, which contributed large numbers of environmental health specialists and facility engineers. The team focused on several areas of restoration: laboratory capacity, immunizations, critical public health facilities (including those providing immunizations, HIV/STD diagnosis, and treatment), and environmental health services. The need was clear as the PRDOH laboratories (a network that consists of three regional and one main laboratory), suffered significant structural damage and environmental contamination from the direct impacts of wind and water intrusion.[37] Because of these impacts, laboratories could not provide several testing services, including tests for food, water, and infectious disease. Power outages resulted in additional losses as sensitive equipment and supplies could not be maintained at the required temperatures or humidity or appropriately quality controlled for accuracy. The PHB coordinated a request for CDC staff to provide laboratory technical staff to PR to assist with the inventory of damages. The Association of Public Health Laboratories, an organization that assists with coordinating emergency responses and assistance to such facilities, sent a four-person team to PR assist with the public health laboratory system assessment.

In addition to damaged equipment and supplies, many other systems necessary to safely operate a laboratory suffered damage or were contaminated, including HVAC systems, roofs, towers, and safety hoods. Testing was suspended for several conditions important to public health, so the PHB assisted with the initial coordination of delivering specimens for testing at CDC laboratories, located in Atlanta, Georgia. The massive power loss also damaged stocks of vaccines in storage, including seasonal flu and routine children and adult immunizations. A seasonal flu vaccination campaign, scheduled to begin only a few weeks after the storms, was postponed until adequate supplies of vaccine and materials were made available. Other severely affected facilities included PRDOH headquarters and specialty clinics serving populations such as young children and people with disabilities.

Throughout the transition to recovery operations, the PHB supported the PRDOH and helped to facilitate requests for a constant influx of experts and consultants to help complete required damage and cost estimate assessments for FEMA. Data and information gathered during those damage assessments allowed for faster allocation of funds for temporary repairs and initial recovery. Records, pictures, narratives of all damages, and cost estimates were provided to the PRDOH, Army Corps of Engineers, FEMA, and other agencies assisting with damage quantification.

FEMA BRANCH LIAISON SUPPORT

Immediately after the storm, FEMA divided the municipalities of PR into four branches. Staff from the PHB were reassigned to fulfill roles as public health liaisons to these branches and provide additional oversight and awareness of local issues. Additionally, this allowed PHB staff greater access to better information and more interaction with municipal agencies and communities about public health needs. However, finding enough bilingual public health staff to fulfill those roles and securing lodging and communication with the embedded teams proved to be problematic when most communications and utilities outside the San Juan metro area were still down. As a result, some of the liaison staff commuted from their base in San Juan several times a week to provide technical assistance to the branches.

DISCUSSION

The disastrous impact of Hurricanes Irma and Maria followed a reprieve of approximately 15 years since the last major hurricane struck the US Caribbean territories. The isolation and vulnerability of the islands presented potential challenges and logistical concerns that are inherent in this area and that must be considered in future planning. Perhaps, a practical approach for enhancing collaboration and assistance in disasters between islands, some within close distance of each other, maybe the use of a “whole of regional community” response approach. This approach may reduce the time required for initial evaluation of impacts by neighboring islands before additional help arrives. The Irma and Maria responses required a multi-agency, coordinated effort that faced unique challenges not typical of hurricane responses in the mainland US—for both victims and emergency responders who faced the same shortages of supplies and resources.

The public health response to Hurricane Irma and Hurricane Maria also highlighted the unprecedented efforts by public health partners to confront and adapt to challenges. Complex disasters require standard tools and methods that are easy to understand and implement even in slow or acute onset disaster situations. The public health agencies in theater successfully adapted to the changing situation and logistical difficulties to focus on upcoming challenges, assess gaps, and adopt an organizational framework for running a safe and effective operation. Establishing an incident management structure, based on effective and focused field activities, helped IRCT leadership, other federal teams, and partners understand the scope of PHB missions.

The public health partners in theater successfully adapted and used existing tools and methods such as public health assessments tools, surveillance concepts, to and communications materials. For example, while conducting shelter assessments, the field team used the CDC tool for disaster shelters. For HCF assessments, a paper assessment tool was used for the initial evaluation of operational capacity, damages, and needs. During the ICOS mission, teams adapted the questionnaire from CDC’s CASPER.[11] Teams modified the tools only to add additional information for leadership to address emerging needs, such as data on morgue capacity and fuel levels.

Often from necessity, new ideas for improving disaster tools and processes may emerge from team members doing the actual work. For example, teams felt burdened by the task of entering data after returning from fieldwork. The PHB leadership worked with response agencies, including FEMA and the PR Planning Board, to develop and implement app-based survey tools for the HCF assessments. The tools reduced the time that took to enter the data, often up to 45 minutes, and expedited availability of critical information. During this response, members of teams doing field assessment activities were trained to use the field tools and tablet-based assessments. As a legacy of this collaborative response, the PRDOH began actively improving and exercising their automated HCF data systems during recovery.

Safety in any disaster field operation is paramount. In natural disasters, the loss of common safeguards, such as communication networks and safe roads, pose additional challenges to the safety of field workers and may limit their ability to travel to the affected sites. In PR, the environmental and structural damage inhibited cellular and electronic communication and impeded access to field sites. The effective collaboration of the PHB, DOD, and local law enforcement agencies provided teams with safeguards to allow them to focus on the mission ahead. Whenever necessary, these liaisons also coordinated air and ground mobility using DOD or DHS aircraft to transport the teams to remote areas of the island. In addition, DOD, VA, and HHS all collaborated in the public health mission in several ways including development and sustainment of a surveillance system, participation in vector control surveillance and control, and initial transport of laboratory samples to CDC for analysis.

Deploying a wide range of senior public health specialists with diverse experience as part of the initial team was critical for the team’s success. Personnel supporting ESF-8 functions bring a wealth of multidisciplinary expertise to a disaster response. During this response, drawing upon that range of expertise on the ground improved mission performance and allowed the experts a firsthand view of the issues. Some issues are unavoidable and both territorial public health agencies needed assistance in coordinating data and information collection. However, efforts toward improving and supporting those systems are ongoing through the on-going recovery phase.

In the VIDOH, a variety of issues resulted in delays implementing vector control. Teams were required to submit a plan of activities to the safety officer for approval before traveling to other parts of the island. Teams often experienced significant delays because of logistics, limited fuel, or safety conditions in the field. Roadblocks, detours, and damaged roads required both additional time and fuel, forcing teams to end their work prematurely. The situation began to normalize after FEMA established several fuel-dispensing points around the island for responders.

During this event, the PHB encountered several challenges, many of which were jurisdictional or agency specific. Though the PHB had surveillance and environmental assessment tools and trained staff to support those activities, access to congregate shelters located around the island of PR to assist with assessments and surveillance activities was limited. One way to improve this collaboration in future may be to establish pre-impact

agreements or memorandums of understanding to support and facilitate the exchange and access of surveillance information from the local jurisdiction.

In addition, in PR the PHB struggled throughout the response to maintain an adequate pool of Spanish-speaking public health workers. Fieldwork required conducting interviews and participating in community meetings and outreach activities in which community leaders, mayors, and organizations exchanged views and information. Bilingual staff capable of fluently communicating and actively participating during those meetings were in short supply. Although FEMA did provide in-kind assistance with translators, many were not specifically trained in public health. Preplanning for a disaster response in an area where most of the residents speak a language other than English should include recruiting bilingual, qualified public health workers.

Finally, whenever possible, advance PHTs should be deployed pre-event. Advance deployment would improve early coordination and integration or resources with local and response stakeholders, provide an opportunity for early planning of needs assessments, and build the relationships and organizational concepts for running a safer and effective disaster response, and subsequently, a swift transition to recovery work.

CONCLUSION

Overall, the PHB demonstrated its utility as a primary resource during and after two major back-to-back disasters affecting both the US Virgin Islands and Puerto Rico. Public health tools and methods utilized displayed the simplicity and adaptability of disaster assessments and other types of monitoring systems in disasters. The systematic integration of public health activities with governmental, volunteer, and military resources in PR and the USVI can served as a model for future disaster planning, regardless of event. For example, disaster relief and nongovernmental organizations such as Americares, the CDC Foundation, the Association of Public Health Laboratories, Mercy Corps, the PR Science Trust, the CDC Dengue Branch in PR, and many others demonstrated how a unified effort can make a difference during a major disaster event.

All disasters are different; however, disaster response starts with evaluating available public health systems and developing a prioritized schedule of targeted activities. During this large, complex disaster response, public health activities were fundamental in providing data and information for action on public health areas. The information collected was also instrumental in ensuring a smooth transition into the recovery phase and help with restoration of public health capabilities system and services. The response to Hurricanes Irma and Maria validated the contributions of emergency public health components across different sectors in promoting the health and wellbeing of everyone affected by a disaster.

ACKNOWLEDGMENT

We would like to acknowledge the work of all the staff from the following agencies who supported the initial response activities of the public health branch: Health and Human Services, Centers for Disease Control and Prevention, Food and Drug Administration, Indian Health Service Health Resources Administration, Agency for Children and Families, Bureau of Prisons, US Department of Homeland Security, US Department of Defense, Department of Veterans Administration Hospital and Clinics, the PR Science Trust, Federal Protective Service,

US Public Health Service Commissioned Corps, PR Rico National Guard, and Puerto Rico's State Agency for Emergency Management and Disaster Management (AEMEAD).

REFERENCES

1. Noji E: The public health consequences of Disasters. Prehosp Disaster Med 2000; 15: 147–157. [PubMed: 11227602]
2. Bathi JR, Das HS: Vulnerability of coastal communities from storm surge and flood disasters. Int J Environ Res Public Health. 2016; 13: 239. [PubMed: 26907313]
3. PAHO Website: Environmental health management after natral disasters. 1982. Available at http://www.disaster-info.net/watermitigation/i/publications/Envhealth/index_en.html. Accessed October 25, 2020.
4. DHS Website: National Response Framework. 2016. Available at https://www.fema.gov/media-library-data/1466014682982-9bcf8245ba4c60c120aa915abe74e15d/National_Response_Framework3rd.pdf. Accessed October 20, 2020.
5. Malilay J, Heumann M, Perrotta D, et al. : The role of applied epidemiology methods in the disaster management cycle. Am J Public Health. 2014; 04: 2092–2102.
6. CDC: Epidemiologic notes and reports surveillance of shelters after hurricane Hugo—Puerto Rico. MMWR. 1990; 39: 41–47. [PubMed: 2104954]
7. CDC: Infectious disease and dermatologic conditions in evacuees and rescue workers after hurricane Katrina—Multiple states, August—September 2015. MMWR. 2005; 54: 961–964. [PubMed: 16195696]
8. Friedrich MJ: Determining the health effects of hazardous materials released during hurricane Harvey. JAMA. 2017; 19: 2218–2285.
9. Sengul H, Santella N, Steinberg LJ, et al. : Analysis of hazardous materials due to natural hazards in the United States. Disasters. 2012; 36: 723–743. [PubMed: 22329456]
10. Cruz MA, Garcia S, Chowdhury MA, et al. : Assessing the congregate disaster shelter: Using shelter facility assessment data for evaluating potential hazards to occupants during disasters. J Public Health Manag Pract 2017; 23: 54–58. [PubMed: 27798529]
11. Schnall A, Nakata N, Talbert T, et al. : Community assessment for public health emergency response (CASPER): An innovative emergency management tool in the United States. Am J Public Health. 2017; 107: S186–S192. [PubMed: 28892435]
12. Cruz MA, Rubens M, Garcia SJ, et al. : Knowledge of and preparedness for use of environmental assessments in shelters during disasters: Results of the 2013 state and territorial use of shelter assessments survey. Disaster Med Public Health Prep 2017; 11: 11–14. [PubMed: 27511727]
13. Kirsch TD, Mitrani-Reiser J, Bissell R, et al. : Impact on hospital functions following the 2010 Chilean earthquake. Disaster Med Public Health Prep 2010; 4: 122–128. [PubMed: 20526134]
14. Nour M, Alhajri M, Farag EABA, et al. : How do the first days count? A case study of Qatar experience in emergency risk communication during the MERS-CoV outbreak. Int J Environ Res Public Health. 2017; 14: 1597. DOI: 10.3390/ijerph14121597. [PubMed: 29257053]
15. National Hurricane Center: Tropical cyclone climatology. NOAA Website. Available at https://www.nhc.noaa.gov/climo/#bac. Accessed October 23, 2020.
16. NY Post Website: Hurricane Irma makes landfall in the Caribbean as a category 5 storm. Available at http://www.weather.gov/sju/maria2017. Accessed October 25, 2020.
17. NY Post Website: Hurricane Maria September 20. 2017. Available at https://nypost.com/2017/09/06/hurricane-irma-makes-landfall-incaribbean-as-a-category-5-storm/. Accessed October 25, 2020.
18. FEMA Website: Virgin Islands Hurricane Maria (DR-4340). Available at https://www.fema.gov/disaster/4340. Accessed October 25, 2020.
19. FEMA Website: Puerto Rico Hurricane Maria (DR-4339). Available at https://www.fema.gov/disaster/4339. Accessed October 25, 2020.
20. HHS Website: Secretary price declares public health emergency in Puerto Rico and US Virgin islands due to Hurricane Irma. Available at https://www.hhs.gov/about/news/2017/09/06/hhs-

secretary-price-declares-public-health-emergency-puerto-rico-us-vi-due-hurricane.html. Accessed October 25, 2020.

21. HHS Website: Secretary price declares public health emergency in Puerto Rico and US Virgin Islands due to Hurricane Maria. Available at https://www.hhs.gov/about/news/2017/09/19/secretary-price-declares-public-health-emergency-puerto-rico-and-usvi-due-hurricane-maria.html. Accessed October 25, 2020.
22. Public Health Emergency: HHS concept of operations for ESF-8. HHS website. Available at https://www.phe.gov/Preparedness/planning/mscc/handbook/chapter7/Pages/hhsconcept.aspx. Accessed October 21, 2020.
23. WHO Website: Communicable diseases following natural disasters. Risk assessment and priority interventions. Available at http://www.who.int/diseasecontrol_emergencies/guidelines/CD_Disasters_26_06.pdf?ua=1. Accessed October 25, 2020.
24. CDC: Emergency Mosquito Control Associated with Hurricane Andrew—Florida and Louisiana, 1992. MMWR. 1993; 42: 240–242. [PubMed: 8459791]
25. Simpson JE: Emergency mosquito aerial spray response to the 2004 Florida hurricanes Charley, Frances, Ivan, and Jeanne: An overview of control results. J Am Mosq Control Assoc 2006; 22: 457–463. [PubMed: 17067046]
26. Tomashek KM, Lorenzi OD, Andújar-Pérez DA, et al. : Clinical and epidemiologic characteristics of dengue and other etiologic agents among patients with acute febrile illness, Puerto Rico, 2012–2015. PLoS Negl Trop Dis 2017; 11(9): e0005859. DOI: 10.1371/journal.pntd.0005859. [PubMed: 28902845]
27. CDC: ESSENCE II and the framework for evaluating syndromic surveillance systems. MMWR Suppl 2004; 53: 159–165. [PubMed: 15714646]
28. Lucero CA, Oda G, Cox K, et al. : Enhanced health event detection and influenza surveillance using a joint Veterans Affairs and Department of Defense bio surveillance application. BMC Med Inform Decision Making. 2011; 11: 56. DOI: 10.1186/1472-6947-11-56.
29. Sanders EJ, Rigau-Pérez JG, Smits HL, et al. : Increase of leptospirosis in dengue-negative patients after a hurricane in Puerto Rico in 1996 [correction of 1966]. Am J Trop Med Hyg 1999; 61: 399–404, 861. [PubMed: 10497979]
30. USDA Website: Animal Health Emergency Management. Available at https://www.aphis.usda.gov/aphis/ourfocus/animal-health/emergency-managementl76UfgVFGQHKgIAHq7ZJA!!/. Accessed October 25, 2020.
31. Everard CO, Everard JD: Mongoose rabies. Rev Infect Dis 1988; 10(Suppl 4): S610S–614.
32. Styczynski A, Tran C, Dirlikov E, et al. : Human rabies—Puerto Rico, 2015. MMWR. 2017; 65: 1474–1476. [PubMed: 28056006]
33. Safe Hospitals in Emergencies and Disasters: Structural, non-structural and functional indicators. WHO Website. Available at http://www.wpro.who.int/emergencies_disasters/documents/SafeHospitalsinEmergenciesandDisasterswebOptimized.pdf. Accessed October 25, 2020.
34. Kile JC, Skowronski S, Miller MD, et al. : Impact of 2003 power outages on public health and emergency response. Prehosp Disaster Med 2005; 20: 93–97. [PubMed: 15898487]
35. Irvin-Barnwell EA, Cruz M, Maniglier-Poulet C, et al. : Evaluating disaster damages and operational status of health-care facilities during the emergency response phase of hurricane Maria in Puerto Rico. Disaster Med Public Health Prep 2020; 14: 80–88. [PubMed: 31658925]
36. Public Health Emergency: Medical assistance. HHS website. 2019. Available at https://www.phe.gov/preparedness/support/medicalassistance/Pages/default.aspx. Accessed July 20, 2019.
37. Concepción-Acevedo J, Patel A, Luna-Pinto C, et al. : Initial public health laboratory response after hurricane Maria—Puerto Rico, 2017. MMWR. 2018; 67: 333–336. [PubMed: 29565842]

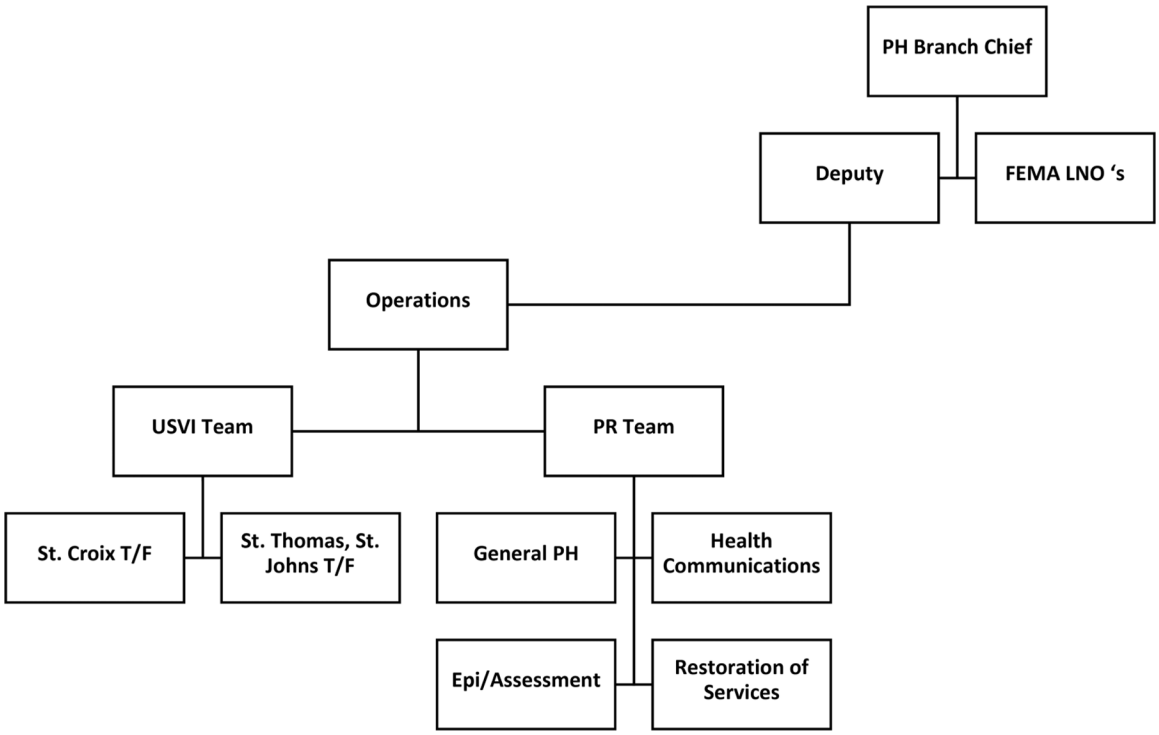

Figure 1.
Organization of the PHB for Hurricane Irma and Maria in Puerto Rico and the US Virgin Islands.