INNOVATIVE APPROACHES TO CONSEQUENCE MANAGEMENT: PROMISING PRACTICES FROM PAST DISASTERS

INTRODUCTION

Consequence management involves strategies and actions to mitigate the effects of disasters and emergencies on communities, infrastructure, and essential services, and it encompasses planning, response, and recovery efforts. Effective consequence management in the 21st century requires innovative approaches, especially when standard systems fail, are attacked, or are overwhelmed.[1] This will be especially true in cases of unprecedented, widespread, and long-term disruption. Prolonged outages or attacks to infrastructure can disrupt telecommunications, healthcare, supply chains, and other critical services that underpin the regular functioning of society. In the event of such an outage, alternative, adaptable, and creative methods of consequence management will be necessary as traditional systems fail.

The Blue Book Project focuses on consequence management that will be needed during a future prolonged infrastructure outage affecting communities majorly across the state of Virginia, one requiring significant innovation to provide services and keep communities functioning as close to normally as possible. This white paper highlights innovative examples of consequence management executed during previous major emergencies that heavily affected critical infrastructure. These examples include Hurricane Helene, a major hurricane that resulted in prolonged outages of critical services; the global COVID-19 pandemic; the Colonial Pipeline outage, a shutdown of a major fuel pipeline in response to a cyberattack; and a large winter ice storm in February 2021 that caused damage to energy and water infrastructure across the United States. These examples may drive further innovative solutions in the case of a major cyberattack on critical infrastructure sector by a malicious actor that results in the disruption of services.

[1] For the purposes of this paper, *innovative* is defined as any creative or novel action taken by a jurisdiction that introduces new methods, products, or services that bring about solutions to existing problems.

HURRICANE HELENE

Hurricane Helene (2024) was a Category 4 hurricane that caused catastrophic damage across the southeastern United States, affecting populations in Florida, Georgia, North Carolina, South Carolina, Tennessee, and Virginia. In particular, Helene dumped an enormous amount of rainfall on the mountainous regions of Western North Carolina, Eastern Tennessee, and Southwestern Virginia leading to catastrophic flooding hundreds of miles away from the storm's initial landfall location. Helene caused damage to multiple critical infrastructure sectors, leaving survivors without water, electricity, telecommunications, or passable road, with Western North Carolina experiencing severe flooding and landslides that devastated many communities.

Rumors and false information

Responding to rumors and false or misleading information. There was so much false or misleading information in the wake of Hurricane Helene that the Federal Emergency Management Agency (FEMA) and North Carolina Emergency Management created dedicated webpages to address rumors and false information in an effort to restore clear lines of communication with the public and avoid any disruption to the emergency response.[1]

Maintaining operations through the storm

Temporary flood walls around key infrastructure. Tampa Bay General Hospital, facing more than 7 feet of storm surge, used Aqua Fence, a water-impermeable barrier that can withstand storm surges up to 15 feet above sea level and 130-mile-per-hour winds. Tampa Bay General Hospital, the region's only Level 1 Trauma Center, was able to maintain operations and avoid moving patients during the storm.[2]

Moving emergency supplies

Enabling the movement of goods. With roads impassable in the wake of Hurricane Helene, there was a scramble to deliver essential goods, including medication, food, and water. Drones were used to deliver lifesaving medication, assess damage, and search for survivors.[3] Two volunteer relief groups, Operation Airdrop and Operation Helo, organized privately owned planes and helicopters, along with volunteer pilots, to deliver lifesaving supplies to people in need in remote and inaccessible locations. Mountain Mule Packers volunteered their staff and their animals to deliver aid in North Carolina, traveling over mountains when roads were impassable.[4] Private-sector companies also worked with local communities to provide water purification systems to shelters and home dispensers and straws to individuals without access to clean drinking water.[5]

COVID-19 PANDEMIC

The COVID-19 pandemic (beginning in early 2020) led to unprecedented global disruptions that affected every level of society. Governments, businesses, and organizations needed to adapt rapidly to the evolving crisis, including many disruptions to normal business and services. The Defense Production Act

(DPA) was enacted in March 2020 to accelerate production of personal protective equipment (PPE), ventilators, and medical supplies. It was further invoked three times within the next year to maintain production of meat and poultry, increase PPE inventories, and to produce vaccines. Additionally, numerous innovative consequence management strategies emerged from the pandemic that addressed a variety of gaps, a selection of which is presented below.

Rapid, direct economic relief

Relief funds. COVID-19 relief packages were provided by a series of state governments to address the economic effects of the pandemic. The speed with which the relief funds were appropriated and expended was unprecedented, and those funds included unemployment benefits, support for small businesses, and direct payments to individuals.[6]

Local coordination networks

Mutual aid networks. With traditional communication channels strained, local grassroots mutual aid networks like NYC COVID-19 Mutual Aid and initiatives such as San Francisco New Deal coordinated deliveries of food and medical supplies to high-risk individuals and to those in need.[7]

Critical goods

Flexible manufacturing. The pandemic led to several notable examples of industries pivoting their production to meet urgent needs. Many distilleries, such as Tito's Handmade Vodka, repurposed their facilities to produce hand sanitizer in response to shortages.[8] In many states, manufacturers of prison garments adapted their operations to include the production of face masks and other personal protective equipment (PPE) for inmates and guards.[9] Automotive firms such as Tesla, Ford, and GM managed to quickly modify their production to manufacture medical ventilators.[10] LVMH, a luxury cosmetics company, manufactured plastic bottles of hand sanitizers instead of perfume bottles.[11]

Preventing fraud and detecting counterfeit goods. During the pandemic, the number of counterfeit goods in the market rose precipitously, especially medical supplies and PPE.[12] The State of Colorado partnered with the Colorado Information Analysis Center to help detect counterfeit PPE.[13] The state also partnered with academic organizations to authenticate and test materials masks and other PPE.[14]

Technology solutions

Remote learning and working. Many schools and businesses transitioned to online platforms to continue operations, and even as companies such as Zoom and Slack saw a surge in usage, the platforms rapidly introduced new features to facilitate virtual meetings, collaboration, and productivity more easily.[15] Along with remote work, many businesses adopted flexible hours to help meet employees' needs during the pandemic.[16]

Online shopping and delivery services. Major retailers such as Walmart and Amazon expanded their contactless delivery options and same-day service capabilities, allowing customers to shop safely from home and receive their products and groceries quickly while minimizing physical contact.[17] At the same time, small businesses established curbside pickup in which, for example, orders were placed in the trunk of a car so that the driver and the retailer never made contact. Many retailers adopted contactless payment systems to minimize physical contact.[18]

Virtual community programs. Virtual programs were created during the pandemic to facilitate community cohesion, mental health, and support while distancing orders were in effect. Platforms such as Nextdoor adapted to offer virtual neighborhood support for groups that helped individuals connect for support including grocery delivery, mental health support, and information sharing.[19] Local organizations such as the New York Public Library launched virtual tutoring, community groups, and educational programs to maintain social interaction and education despite physical closures.[20]

Expansion of telehealth. Healthcare providers rapidly transitioned from in-person visits to virtual visits to allow patients to receive care without the risk of infection. Telehealth platforms themselves expanded rapidly not only to increase bandwidth, but also to integrate electronic health records and share data among hospitals, clinics, and specialists.[21] The Centers for Medicare and Medicaid Services (CMS) expanded reimbursement for telehealth services, and restrictions on providing telehealth services across state lines were lifted.[22]

Wastewater testing. Although wastewater testing has been in use as a public health tool for decades, it emerged as a critical tool during the COVID-19 pandemic. Wastewater testing allowed early detection of outbreaks. Many cities and counties established testing programs to monitor COVID-19 trends locally and used the data to inform policy decisions.[23]

COLONIAL PIPELINE OUTAGE

The Colonial Pipeline ransomware attack (2021) significantly affected fuel supply and energy distribution to the public for a prolonged period of time and required innovative strategies to manage disruptions. Effective communication and logistical coordination were crucial to managing the response to fuel shortages.

Physical supply chain solutions

Local fuel storage solutions. The city of Atlanta set up temporary fuel storage facilities to manage distribution of fuel and alleviate crucial shortages around the country. These allowed rapid scaling and adjustment based on changing demand and distribution needs.[24]

Innovative fuel distribution. Fuel was transported and distributed using unconventional and highly collaborative methods to expedite distribution and delivery to critical areas. Fuel needs were met by drawing down inventories, increasing imports, and using Jones Act shipments.[25]

Government intervention

Emergency fuel waivers and regulatory flexibility. The Department of Transportation issued emergency declarations to facilitate alternative fuel transportation methods. The Environmental Protection Agency

(EPA) issued emergency fuel waivers to areas affected by the colonial pipeline shutdown to temporarily relax regulations on fuel composition and distribution. These efforts helped increase the availability of fuel during the crisis by allowing the sale of nonstandard fuel blends and extending the allowable driving hours for fuel trucks to alleviate shortages.[26, 27, 28]

Public outreach and coordination

Digital signage and apps. Digital billboards and city apps were used in multiple cities to provide real-time updates on fuel availability and transportation restrictions during the outage.[29]

FEBRUARY 2021 WINTER ICE STORM

The February 2021 winter storm caused widespread power outages and severe disruptions across many states, particularly the southern United States. Coordination between public and private sectors and infrastructure solutions to mitigate the damage caused by the storm were needed.

Water distribution and management

Mobile water distribution units. In response to water system failures and boil water notices, the city of Houston, Texas, deployed mobile water distribution units to provide clean drinking water directly to residents who were affected by water system failures. Mobile units included filtration systems and dispensing stations and were strategically positioned in high-need areas.[30]

Public-private partnerships for resource deployment. In Austin, Texas, local government agencies collaborated with private companies to manage water distribution and ensure supply continuity. Austin Water, for example, worked with private companies such as major grocery chain H-E-B to leverage their logistics networks and resources.[31] Similarly, the Austin-Travis County Emergency Operations Center coordinated with private sector partners to distribute shelf-stable meals to residents.[32] These partnerships facilitated the rapid deployment of water and power resources to affected areas.

Public information and safety

Interactive online maps. Governments, news outlets, nonprofit entities, and utilities leveraged interactive online maps to share real-time data on power outages, road closures, and emergency resources. For example, the Houston Advanced Research Center developed a map that tracked electricity outages, boil water notices, and elevated industrial emission events across the state.[33] Interactive maps are useful tools for responders and the public alike to track effects and make informed decisions.

Pop-up warming centers. Cities including Dallas, Texas, set up pop-up warming centers in nontraditional locations such as libraries and convention centers, which were equipped with generators, medical supplies, and volunteers.[34] These centers were crucial in addressing public needs and were a novel way to offer shelter and warmth in centralized locations that could also be quickly adapted for emergency use.

Community-driven assistance networks. Local organizations and grassroots groups organized volunteer networks to deliver essential supplies and offer assistance with home heating. This approach used local knowledge and networks to fill gaps in formal emergency response and showcased a community-driven model for emergency assistance that complemented the official state response.[35]

EMERGING TECHNOLOGIES

Many emerging technologies demonstrate potential for future events. Some of these technologies are not currently used on a large scale or may be out of reach for most emergency management agencies. As these technologies continue to develop, they may become sufficiently mature or accessible to be deployed more regularly or on a larger scale.

Unmanned aerial vehicles. Drones can be used to establish temporary communications networks, conduct surveillance, deliver critical supplies, assess damage, detect pollution, identify survivors, and create detailed 3D maps of disaster sites.[36]

Artificial intelligence. Platforms powered by artificial intelligence (AI) can process data rapidly from social media, satellite imagery, sensors, and other sources to provide real-time insights and support decision-making. AI can perform predictive analytics to anticipate the effects of incoming disasters, allowing emergency responders to prepare and allocate resources more effectively. AI chatbots can be used to handle high volumes of calls and inquiries during emergencies.[37]

Blockchain for secure financial data sharing and transactions. Blockchain technology provides a secure architecture that can speed up financial transactions and processing times for disaster assistance and insurance benefit claims while providing transparency to prevent fraud and misuse.[38]

Robotics. Ground-based robots may be used to navigate hazardous environments, such as those filled with debris, to find survivors or deliver supplies. Robots may facilitate the cleanup of debris, including hazardous materials, without putting human responders at risk.[39]

Big data and crowdsourcing. Big data analytics platforms can combine information from social media, news outlets, and other sources to track effects of disasters. Analyzing mobile phone data and Global Positioning System (GPS) data can help track population movements through a crisis.[40]

3D printing. 3D printing technology can be deployed to a disaster area to produce medical supplies, temporary shelters, tools, and other critical supplies, such as water filters.[41]

CONCLUSION

From technology- and community-based solutions during the COVID-19 pandemic to public-private partnerships during severe weather events, these examples underscore the critical role of innovation in emergency mitigation. The examples and solutions laid out in this white paper highlight the importance of adaptive and multifaceted approaches to manage emerging crises. The insights gained from these scenarios demonstrate the following key takeaways:

1. Leverage technology to provide real-time updates, resources, and solutions to the public in constantly and quickly evolving crises.
2. Ensure logistical flexibility by using mobile distribution units, temporary storage facilities, and microgrids to ensure effective response efforts and resource management.
3. Promote robust coordination and collaboration among public authorities, private-sector partners, and community organizations to ensure a unified and efficient response.

The threat of a major cyberattack on critical infrastructure may produce unprecedented challenges across affected areas. In the face of prolonged outages and significant disruptions, effective and innovative consequence management is crucial for maintaining community resilience and operational continuity. The Blue Book Project is working to identify innovative strategies that may be leveraged during future critical outages to help overcome these challenges and reduce disruption to residents' lives and livelihoods.

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