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Silence is Not Golden: Exploring the Trade-Offs Between Transparency and Burden in DIRS Reporting

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Silence is Not Golden: Exploring the Trade-Offs Between Transparency and Burden in DIRS Reporting

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Abstract

This study explores the United States federal government's Disaster Information Reporting System (DIRS), which is an instrument that is used during emergencies to gather information on what five communication avenues are not actively working at the time of the emergency or during the recovery process. The synthesis provides a framework for characteristics that cite the necessities for this study on DIRS. Examining DIRS will help us understand its strengths, limitations, and potential improvements. Evaluating the details of historical and global research on emergency communications are gathered. The analysis provides insights into DIRS's past, present, and future. Bring to light future changes in DIRS to contemplate.

Keywords: Disaster Information Reporting System (DIRS), emergency communication, Hurricane Katrina, disaster, Planning, Federal Emergency Management Agency (FEMA), Federal Communications Commission (FCC), and Wireless.

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Chapter I: Introduction

After a large disaster ravages a region of the United States, no sound, not even the smallest peep, can be heard because the community is left in pure shock. Then, the calls for help come, flooding in from every corner and all directions. First responders become overwhelmed with the requests, systems are overloaded with the data, and prioritizing can be difficult. In 2005, the calls for assistance were not processed by first responders, nor by the federal government. Likewise, communication systems did not process the requests for help after large-scale disasters. That silence changed emergency communication and led to what today provides information to citizens at a faster rate to help those in need more quickly than ever before.

In 2005, Hurricane Katrina was one of seven hurricanes that affected the United States. Hurricane Katrina changed emergency management communications, as it is known today, due to the lack of communication observed by the entire country on national television. The breakdown of communication occurred at various levels in several government agencies, as well as private sector communication organizations, within the United States (U.S. Department of Commerce National Oceanic and Atmospheric Administration, 2023). The impact of Hurricane Katrina brought about the Disaster Information Reporting System (DIRS) within the Federal Communications Commission (FCC), which marked a change in interactions between the federal government and communication organizations. Disaster Information Reporting System (DIRS) provides critical information concerning disruptions of communication services in wireline, wireless, and broadcasting, to name a few of the outreach services available to the communities affected by devastating emergencies (Federal Register, 2020*).*

Purpose of the Study

For this study, data from DIRS will be evaluated to see what is currently evaluated in the system. In the future, applications and services that are used in a disaster may be considered due to the importance of providing resources to first responders. The information detailed in the communication report provided by the FCC to the public does not connect to the assistance or decision-making needed to quickly utilize other applications. For example, an application that helps with depth perception in flooding is not useful if the National Guard cannot access it to carry out rescue efforts.

The purpose of this study is to evaluate the prior effectiveness of DIRS and the future viability of this system in relation to current technologies that provide communication and potential life-saving measures in disaster relief. Considering the impact of the historical communication infrastructure after a disaster, this study will examine whether DIRS is still reliable and effective. With the changing of technology over the last 19 years, including smartphones, applications, and alternative technology, should DIRS expand communication reports provided to the public to accommodate this change and grow with society?

Conceptual Framework

Emergency communications in the United States started with the Red Cross, and grew following published requests for help after the devastating Galveston Hurricane of 1900 (Rubin, 2012). Then, communications progressed with the San Francisco Earthquake of 1906. Emergency communications were a concern during the 1918 Great Influenza Pandemic and the 1927 Mississippi Flood (Rubin, 2012). Then, in 1947, the Texas City Explosion brought on a different issue, that of rumors spread following an emergency. The rumors caused additional turmoil in the aftermath of the explosion. In 1974, the Disaster Relief Act of 1974, a federal program for disaster preparedness was launched to progress communications on disasters in the United States (Rubin, 2012). Later, in 1984, the National Coordinating Center for Telecommunications (NCC) was established in collaboration with the telecommunications organizations in the United States (Select Bipartisan Committee, 2006b).

In the past 17 years, emergency communications have evolved with advances in technology, where mobile and smartphones have replaced reliance on landlines in homes and businesses. Affecting the emergency communication process is the government's difficulty maintaining pace with technology and public use of communications in an emergency. DIRS reporting was meant to highlight the lack of communication services during an emergency. The 2022 FCC, which handles DIRS, has changed communication by developing the wireless network resiliency cooperative framework as part of the Mandatory Disaster Response Initiative (MDRI). The goal was to make the Resilient Network notice mandatory for all providers and establish coordinated efforts for roaming agreements to standardize responses (Federal Communications Commission, 2022). With the strength of federal, state, and local backing, governments have initiated the use of short message service (SMS) with warning alerts to deliver notifications in an emergency. Federal wireless emergency alerts (WEA) are another higher level of communication from the federal government (Stephens, 2019).

The start of DIRS arose due to the effects of natural disasters in 2005. Hurricane Katrina was predicted to be a category 4 to 5 hurricane with winds up to 160 mph (National Oceanic and Atmospheric Administration, 2024b). A hurricane that is rated at a level 5 on the Saffir-Simpson Hurricane Wind Scale is considered to have homes destroyed, fallen trees, and downed power poles. Power outages in the affected area can last more than a week, possibly up to a month (National Oceanic and Atmospheric Administration, 2024b).

With the evacuation orders for New Orleans, the state of Louisiana requested a declaration of a state of emergency from the federal government. Later, Hurricane Katrina made landfall as a category three hurricane with winds of 126 mph (Horowitz, 2020). The hurricane affected the levees that then breached in and around New Orleans. Requests for assistance with the evacuation of citizens took seven days to process (Horowitz, 2020). Communication lagged in this instance partly because communication services in the area were not able to help due to having no power and the inability to access generators. Damage to the cell site towers, including transport of T-1 and microwave, further hampered communication efforts (Select Bipartisan Committee, 2006a). Due to the hurricane, 2,000 cell sites were out of service, and a month later, 820 cell sites in the affected area were still silent, with the majority in the New Orleans area. Other communication services, such as satellite phones in Louisiana for emergency use, were available from 1999 to 2004 but stopped when the state stopped paying the monthly fee for the service. Mississippi's communication system was demolished in the southern half of the state. Alabama was not as affected by Hurricane Katrina as Louisiana and Mississippi since it had multiple communication methods, including LINC radios, satellite phones, and wireless cell phone services (Select Bipartisan Committee, 2006b).

Between 2005 and 2017, which is when DIRS was being established, large disasters still occurred from flooding, tornados, and wildfires across the United States. The lack of communication was noticeably different this time with Hurricane Ike in 2008, with clear communication of evacuation of vulnerable citizens in the affected area (Bedient, 2012). During Hurricane Ike, effective Disaster Communications Plans reported on the status of the area (Bedient, 2012). Away from the coast in 2011, a tornado affected Joplin, MO, causing 161 (Kuligowski, 2020). The difference between Hurricane Ike and the tornado in Joplin, MO, is that citizens in Joplin, MO, had 20 minutes to look for shelter after the first siren sounded.

Communication with a tornado needs to be quick compared to a hurricane making landfall (Kuligowski, 2020). In 2012, a hurricane did not affect the Gulf Coast, but rather the northeast region of the United States with what was later called Hurricane Sandy. Hurricane Sandy brought in a higher volume of social media communications compared to past disasters due to the lack of access to traditional communication services caused by flooding (Sadri et al., 2017). Hurricane Matthew in 2016 brought about a different subject of communication while waiting for DIRS to be finalized, with improving communication for older adults during a disaster (source?). In 2016, older adults were less on social media than other age groups that (Gibson et al., 2020). While Hurricane Matthew was on one side of the Appalachian Mountains, just a few months later, the Great Smoky Mountains Wildfires were on the other side. Communications fell to a 20-year-old siren system to alert the area. The original siren was actually built for flooding. Following the fires, a new system was developed. With visitors coming to the Gatlinburg area, one of the many features of this new system is sending text messages to any wireless or wireline in the area that needs to be evacuated (Hickman & Lakin, 2018).

The change has also brought concerns. In 2017, for example, California decided not to use the system during the Sonoma County Wildfire that killed 44 people (Stephens, 2019). The following year, a false alarm from WEA was sent out to people in Hawaii that a missile had launched towards them and to seek shelter (Stephens, 2019). In August 2023, the lack of communication and understanding of the situation in Maui, HI, became apparent to the world. When winds increased in the Maui area, power lines connected with dry debris in the area sparked a deadly fire (Mittelstaedt, 2023). Communication methods have changed, and it is important that governments use new options effectively.

Communication for help can come in various forms, including just-in-time media communication with live media provided by television and radio, which is essential for those outside the affected area to see the need and support the affected people (Browning et al., 2010). Just-in-time communication can spread globally once communication systems are connected after a disaster has hit an affected area. Other options include local wireline, wireless, or satellite communication systems. Media can also provide expert viewpoints and information that may benefit those affected (Browning et al., 2010). A lack of communication in an area affects the ability to assist in a disaster, ultimately impacting everyone involved in rebuilding. The absence of trust between public and private organizations can affect each phase of emergency communication, undermining the perceived accuracy of the information provided and impacting how individuals respond to a large-scale emergency (Abrashoff, 2012). If trust already exists, then communication between groups will flow smoother during an emergency, and the response will be quicker for those in need. Building communication before a disaster helps reduce friction during the disaster (Abrashoff, 2012).

Trust and communication will help citizens affected by a significant emergency (Abrashoff, 2012). Leadership from state government officials preparing for an emergency helps build trust with the citizens affected by the emergency (Abrashoff, 2012). In an emergency, it is not one individual working. Instead, everyone works together to be successful for the greater good of the affected community (Stephens, 2019). Analyzing data on disruptions in communication infrastructure can come in various forms, from news reports to social media posts. The study's data were divided into three classifications based on whether the disruption had a positive, negative, or neutral effect on social media. The disruption map will help show each negative, positive, and neutral data classification (Roy et al., 2020).

Emergency communication was originally traditionally processed using newspapers, television, or the radio, which are methods of one-way communication. Many people who work in emergency work were affected in their personal lives at some point in their lives or are children of a responder. In a TED Talk, the author brings up an account of the personal effect of how emergency communication was communicated to their family, which is brought to light by the speaker's home being affected by flooding, and changed her as an adult by bridging the gap of emergency communication (Stephens, 2018). Ways individuals can improve communication are by helping coordinate, communicate, and save lives. The lack of communication between systems can lead to one community having access to information, while a neighboring community does not (Stephens, 2018). With the change of social media added to emergency communication, a two-way process for communicating was developed for helping during an emergency. Social media helps with necessities, for example, tree removal from their property, that are not considered true emergencies for which someone would call the 911 system.

Communication can also come from citizens alerting government agencies to emergencies from social media, such as an earthquake or civil unrest in the area. Agencies can also use the data to find the heavily affected areas (Houston et al., 2015). Social media monitoring has become the norm for many local agencies nationwide. The concern at the federal government level is that research by the US Congressional Research Service shows that adopting social media during emergencies would be costly to the federal government. The benefit is that social media provides time-critical data to facilitate discussions and communicate effectively with the local area (Imran et al., 2015).

Scalability and content issues are both challenges with social media in massive emergencies. Scalability issues are due to the data size, including the influx of data at a rapid rate (Imran et al., 2015). As an example, if an F5 tornado that has hit the area and everyone in the area is posting online, that could limit the accessibility of safety communications coming through on those platforms. The second issue is content due to the lack of or inaccurate information posted on social media (Imran et al., 2015). Within the self-organization of fundamentals of the density of data, alternative means of gathering, producing, and providing communications have emerged, moving from formal communication structures to an alternative path of gathering valuable data in an emergency to help save lives and rebuild after a disaster (Browning et al., 2010). Utilizing other means of communication has formed a new path in evaluating data after a disaster (Browning et al., 2010). With the growth of social media and software phone applications, the data being provided will expand the alternative path of information into more formal channels. This change is due to the increased capabilities of these applications and the easy access they provide after a disaster (Browning et al., 2010).

Supplemental communication may also come from other service providers in the affected area. Service providers can include competitors in the same service and work together to provide service. The notice of utilizing another communication organization's services for the organization that has no service to provide to their customers is a mutual agreement set in place during a declared disaster for competitors to work together to provide service to all customers in the affected area of the declared disaster (Federal Communications Commission, 2019). DIRS' main data elements are brought into supplemental communication with considerations of the percentage of cell sites down by county (Federal Communications Commission, 2019). Research, evaluation, and working together will also reduce the resilience gaps of recovering swiftly after an emergency with the work of all parties involved in emergency communications in planning.

Emergency communications do not just happen in the United States; the technique also happens globally. Each country has its own unique situation in terms of how it handles emergency communications. To understand and improve the United States, it is beneficial to look outside of the country to evaluate other perspectives and see what is working in other countries. For example, it can help to see how countries in Africa, as opposed to North America, lack communications regarding humanitarian efforts. The United States can use this knowledge and learning to improve our humanitarian efforts after a natural disaster has occurred at home (Franks, 2010). Canada has a different communication system due to the terrain of the country and has found benefits with regal communications with the Regional Emergency Operations Centre (ROEC), which the United States also utilizes and is similar to county emergency operations centers that report to the state that a natural disaster has occurred (Vaillant, 2023). Australia takes the ROEC a step further by empowering the community with preventive measures to reduce or eliminate potential emergencies with community involvement, including contributions from residents, local government, and organizations (Haworth, 2018).

The benefits of Taiwan are that it breaks down disasters into three aspects: emergency management center, disaster response, and disaster prevention. The theory of disaster prevention breaks down the complexity of the factors due to the different types of disasters that affect Taiwan compared to other countries that may have one or two types of disasters to consider (Chen & Hsu, 2019). The National Communications Commission in Taiwan created the Disaster Prevention and Response Act to help plan, coordinate, and assist in bringing to light imperfect laws and regulations affecting communications at each level during planning and in an emergency (Chen & Hsu, 2019).

Research Questions

RQ1: What were the major impacts of communication infrastructure made post-disaster since 2000?

RQ2: How do bureaucratic bureaucracy issues impact communication infrastructure before, during, and after a disaster?

RQ3: What is the prospect for sustainability of the Disaster Information Reporting System (DIRS)?

RQ4: What are potential changes that might benefit the Disaster Information Reporting System (DIRS)?

Significance of the Study

The study will contribute to existing research on disaster communication and how that communication has changed since DIRS reporting was implemented. The study will evaluate the data reported in DIRS, including data from federal agencies and communications organizations.

Definitions, Terms, Symbols, Abbreviations

- Application Programming Interface (API): Programming language that enables software applications to communicate with each other and exchange data. (Goodwin, 2024).
- Artificial Intelligence for Disaster Response (AIDR): AI tools to classify data from social media from a disaster (Imran et al., 2014).
- Disaster Information Reporting System (DIRS): Voluntary web-based system that collects the operational status of communications restoration after a disaster.
- Emergency Operations Center (EOC): Central location where a city, state, and/or federal agency communicates a plan of execution with multiple groups in one primary location

(Federal Communications Commission, 2019).

- Federal Communications Commission (FCC): Government agency regulating communications within the United States (Federal Communications Commission, 2024b).
- Federal Emergency Management Agency (FEMA): Part of the Department of Homeland Security and is to help before, during, and after a disaster (Federal Emergency Management Agency, 2024).
- Geographic Information System (GIS): Digital mapping of a location or items in a location (Douglas et al., 2019).
- Information and Communication Technology (ICT): Diverse technology used to transmit and share communications (Ali et al., 2017).
- Mandatory Disaster Response Initiative (MDRI): Mandatory notice for all providers to establish and coordinate efforts for roaming agreements to standardize responses (Federal Communications Commission, 2022).
- National Coordinating Center for Telecommunications (NCC): Partnership with telecommunications organizations in the United States (Select Bipartisan Committee, 2006b).
- National Oceanic and Atmospheric Administration (NOAA): Federal department to monitor weather and climate (National Oceanic and Atmospheric Administration, 2024).
- National Response Plan (NRP): Multi-agency approach to emergency response in the United States (Annelli, 2006).
- New Event Detection (NED): Software to detect new emergencies presented on social media platforms (Imran et al., 2015).

- Regional Emergency Operations Center (REOC): Regional-level Emergency Operations Center that communicates with the State Emergency Operations Center (Vaillant, 2023).
- Short Message Service (SMS): Warning alert to make quick notifications in an emergency (Stephens, 2019).
- The Virtual Emergency Operations Center (VEOC): Community effort to help report real-time data on road issues (Lowrie et al., 2022).
- Volunteered geographic information (VGI): Information gathered and provided by volunteers during a natural disaster (Fazeli et al., 2015).

Summary

Reports of emergency communication effects are vital to all stakeholders involved, from the 911 operator processing a call to the United States Secretary of Homeland Security. Vital information is needed in a disaster to enhance everyone's safety, to reach loved ones, and to ensure that help is on the way. In 2005, information processes changed due to the breakdown of communication in Hurricane Katrina. That failure led to a new way of ensuring that communication services were processed before, during, and after a disaster. If an issue arose, the information was reported to the federal government to inform them that a communication breakdown was affecting an area after a disaster. The Disaster Information Reporting System (DIRS) is handled by the Federal Communications Commission (FCC) of the federal government.

The United States, and the world, has changed in the last 19 years with faster internet services, fiber instead of T1, and smartphones instead of flip phones. The purpose of the study is to determine whether the DIRS process is viable in today's and if changes should be made to DIRS to accommodate the development of technology over the last 19 years. This study will evaluate the aforementioned research questions to determine the impacts, sustainability, and potential expansion of the DIRS system. The significance of the study is to consider the expansion of DIRS and additional technology for future system reporting that could be beneficial for all stakeholders involved in a disaster, where information can possibly come from applications, social media, or new technology.

Chapter II: Literature Review

During a natural or manufactured emergency, communication is essential to those needing assistance and to the agencies providing aid. Keeping the safety of all parties in mind is necessary when evaluating the proper necessities within the process of a large-scale emergency. In 2005, the lack of communication after Hurricane Katrina came to light, which changed how the federal government handles emergency communication pre-, during, and post-emergency (Federal Communications Commission, 2024). Communication around Hurricane Katrina was not well-established within the federal government, and their silence placed many citizens in harm's way after the hurricane. Since Hurricane Katrina, technology, people, and disasters have changed. Also, consider how other countries outside the United States handle emergency communications. Natural and manufactured emergencies have been around for years, and communication can impact each emergency uniquely to help or hurt during that time of need. Manufacture emergencies are influenced by human nature and can include fires started by power lines causing a wildfire or a destructive nature by a person that causes an emergency.

History of Emergency Communication

Emergency communication has been part of the United States since the Red Cross was chartered in 1881. Today, it is part of their charter to provide family communications to the U.S. military. Communication concerns are noted as far back as the Galveston Hurricane of 1900 via the U.S. Weather Bureau. Population centers have grown closer to the coast and other weather-prone areas, and communication impacts have also grown over the years (Rubin, 2012). Emergency communications are also critical with earthquakes as well, starting the San Francisco Earthquake of 1906, in which, it was documented that the lack of communication caused the fires that broke out due to the earthquake to cause further destruction. Communication also affected the spread of the 1918 Great Influenza pandemic, with communication was ineffective to reduce the spread. The 1927 Mississippi Flood had an absence of communication from upstream breaches of the river that there was no need to reduce the amount of pressure on the levees in New Orleans, LA, with dynamiting the levees to reduce the pressure that was affecting the city (Rubin, 2012). Dynamiting the levees in the city caused additional flooding that was not necessarily due to the work that happened upstream. In the aftermath of the 1933 Long Beach earthquake, there was a quick response from the military, but many residents believed they were under martial law due to a lack of communication in the midst of the emergency. During the time of the 1947 Texas City Explosion, emergency personnel not working with the media brought on a new issue of inaccurate information being passed on about the event (Rubin, 2012).

It was not until 1950 that a substantial presence of emergency management and communication was formalized due to the lack of communication structure and the increase in disasters. This presence grew more in the 1970s with the introduction of legislation in 1974 with the Disaster Relief Act of 1974, establishing a federal program for disaster preparedness. The program helps with setting up an emergency communication system through the collaborative efforts of private and federal organizations. Due to the change, presidential disaster declarations became a way to communicate a disaster and provide a response from the federal government. From May 1953 to September 2005, a total of 1,118 presidential disaster declarations were approved (Rubin, 2012). Two years later, a new emergency communication came about with the Disaster Information Reporting System (DIRS), led by the Federal Communications Commission (FCC) (Federal Communications Commission, 2024).

Pre-Katrina

The Gulf Coast area of the United States has seen a steady of hurricanes dating back to 1915 (Horowitz, 2020). The 1915 hurricane affected the area, with 275 deaths in the state of Louisiana and a few towns being washed away. Despite devastation and high death tolls, the city of New Orleans affirmed from the 1915 hurricane that the city could prosper with little impact from future storms that reached the city. Ninety years later, the confidence in the area broke when the levees were no longer positioned. The area affected by Hurricane Katrina is the area of New Orleans that grew after 1915 (Horowitz, 2020). The historical communication of the growth affected the confidence of New Orleans for over 90 years. The change in 1915 with the addition of levees affected Hurricane Katrina, with areas that had homes built before 1915 in the city of New Orleans not affected. The areas developed after 1915 were affected by the flooding of levees that broke after Hurricane Katrina (Horowitz, 2020).

Communication concerns date back to 1955, when the tornadoes in Udall, Kansas, affected the community (Minick, 2023). The lack of warnings resulted in the loss of 77 lives. During that time, the communications process from the National Weather Service was conducted via a teletype, which was used to send messages by telephonic signals. Communication was slower in rural areas, with newspapers being sent by airplane to smaller towns and then to a local person to deliver. News media television that night led anyone in the town to believe a tornado would affect their lives. Communication of the incoming emergency in Udall, Kansas, could have reduced the lives lost by having citizens in a safe place instead of in bed on the second floor of a two-story house or hanging out with friends at the local pool hall. Delayed communications occurred via a National Guard mobile radio and operators communicating from the sheriff's department. Another piece that has not changed since 1955 is the willingness of others to help after an emergency, transporting those affected to the hospital and acquiring supplies to help them recover.

Today, there is constant communication from multiple avenues. Research shows how emergency communication has changed over time and how we need to increase communication avenues before, during, and after a large-scale emergency (Minick, 2023). Disasters and communication did change as new technology evolved from 1955 to 1984 to improve response time and procedures of what to do after a disaster has affected the area. In 1984, the National Coordinating Center for Telecommunications (NCC) was established to coordinate with telecommunication industry services and the federal government during emergencies to respond to crises and restore services to the area being affected by an emergency. After Hurricane Katrina, the Emergency Communications Division was established to strengthen emergency preparedness communications (Select Bipartisan Committee, 2006b).

During Katrina

On Saturday, August 28, 2005, Hurricane Katrina moved from Category 4 to 5 with winds up to 160 mph, prompting evacuation orders for New Orleans (Horowitz, 2020). On the same day, the governor of Louisiana requested a State of Emergency from the federal government. The next day, it was predicted that the levee system around New Orleans would be affected by the storm surge. Due to the storm's movement and the lack of transportation, only 75% of New Orleans' citizens evacuated (Horowitz, 2020).

Since the hurricane arrived with less wind than predicted, Katrina made landfall as a Category 3 hurricane with winds of 126 mph (Horowitz, 2020). The hurricane eye also missed New Orleans by 20 miles. Due to the weakness of the storm and New Orleans not receiving a direct hit, the Federal Emergency Management Agency (FEMA) considered New Orleans not harmed by the storm. However, the hurricane affected the levee system 20 miles away, with nearly 50 levee breaches in and around New Orleans. Of the official 971 deaths caused by Hurricane Katrina, 682 were in the city of New Orleans. Many believe the number of deaths is higher, and due to the storm being problematic in multiple ways, it is a challenge to represent an accurate number. The lack of communication also affected critical hospital services, including in Charity Hospital in New Orleans, which was later closed due to the damage from the hurricane (Horowitz, 2020). Due to the lack of support from FEMA, it took seven days for buses to arrive to evacuate people from New Orleans (Select Bipartisan Committee, 2006b). On September 12, 2005, 14 days after Hurricane Katrina made landfall, FEMA Director Michael Brown resigned from his position (Horowitz, 2020). During the 14 days, it was shown in the emails being sent by Mr. Brown that there was a lack of communication and decision-making regarding Hurricane Katrina. The emails also show the lack of communication with high-ranking officials, including the President of the United States at the time (Select Bipartisan Committee, 2006b).

Hurricane Katrina affected communications, with cell sites losing power. The cell sites did have generators, but refueling the generators was impossible due to the flooding and debris, which affected the communication in the area. If a cell site was up and running, other issues could affect communication, from damage to the tower, antennas moved due to the wind, or communication utilizing microwave backhaul from one tower to the next affected due to not being aligned from high winds. Also, at the time, T-1 lines were being used, and if the line was damaged or broken, people might be able to talk to people using the same cell site but not communicate with others outside of that small footprint. The restoration of cell sites was slow and tedious due to the multiple issues after the hurricane made landfall. During this time, little communication came from satellite telephones, and mutual aid channels were used to communicate (Select Bipartisan Committee, 2006a).

Post-Katrina

The documentary, documented by Buckles (2022), brings in the perspective of how the lack of communication during Hurricane Katrina affected children with a lack of fundamentals of food, water, and shelter when the storm hit New Orleans in 2005 (Buckles, 2022). This film sheds light on the human aspect of how the lack of emergency communications affected those amid the disaster. The lack of a Disaster Information Reporting System (DIRS) slowed the communication coming out of New Orleans, and the documentary brings to the front the effects of no support after Hurricane Katrina on the people of New Orleans who stayed during the hurricane. The documentary illustrates the lack of communication during large disasters and how communications before, during, and after disasters are necessary for a community to start the process of coming together and rebuilding in New Orleans (Buckles, 2022). The documentary shows that several years after Hurricane Katrina, the city still showed the effects of the lack of communication from abandoned homes and slow rebuilding.

Post-Katrina, the documentary by Buckles, illustrates the lack of communication during large disasters and how communications before, during, and after disasters are necessary for the community to start the process of coming together and rebuilding in New Orleans. Specifically, the focus is on the lack of communication between children, adults, and the community (Buckles, 2022). The documentary shows that several years after Hurricane Katrina, the city still showed the effects of the lack of communication from abandoned homes and slow rebuilding (Buckles, 2022).

The communication around rebuilding communities and moving citizens from one community to another affected many areas of New Orleans. The moving of citizens into trailers also highlighted the lack of communication about another emergency, which was hazardous living conditions due to living in FEMA trailers, including one of the hazards being formaldehyde found in FEMA trailers used after Hurricane Katrina for temporary housing (CBS News, 2012). The trailers' utilization at the time caused medical issues for children and adults that affected their health even after moving out of the trailers. A federal judge 2012 awarded $42.6 million to victims exposed to the hazards while living in the trailers (CBS News, 2012).

Due to the hurricane, 2,000 cell sites were out of service, and a month after Hurricane Katrina made landfall, 820 cell sites in the affected area were silent, with the majority of the cell sites in the New Orleans area (Select Bipartisan Committee, 2006b). Another affected was 911 call centers, with 38 not operating after Hurricane Katrina made landfall, after a month, two of the centers were not up and running. The concern is that the 20 million calls were not processed until the day after the hurricane. With a large-scale disaster, first responders may have the data available but not be able to comprehend how bad the situation is when having the data to communicate effectively what is needed and where to be successful to the affected citizens (Bowin et al., 2019). Another alarm was the lack of communication for the emergency responders with the communication system they were using at the time, which had not been updated since 1996. The system used by first responders in Louisiana included 46 tower sites across the state. The parishes used satellite phones in Louisiana for emergency use from 1999 to 2004 but stopped when the state stopped paying the monthly fee for the service. The state of Mississippi's communication system was demolished in the southern half of the state due to the strong winds of the storm. With the loss of cell towers, communication lines for landlines, and local communication systems utilize by police and fire departments (Select Bipartisan Committee, 2006b).

Alabama was not affected as drastically by the hurricane as Louisiana and Mississippi, as the state used a unique system of LINC radios and had a more substantial preparedness plan with mutual aid and supplementary services essential in an emergency situation (Select Bipartisan Committee, 2006b). Part of Alabama's preparedness plan was to have multiple communication types of service avenues and staff trained to utilize the various services ahead of time. Alabama’s services utilized encompassed LINC radios, Satellite phones, and amateur radio operators to provide lines of communication for assistance. Mississippi did have backup communication with satellite phones to at least have a slight communication system with the state's southernmost counties. Amateur radio operators were also used during Hurricane Katrina to assist hospitals and communicate in the affected area. The most significant effect of the communication system was the absence of power feeding the communication system, as power was predicted not to be restored close to 16 weeks later in the areas hardest hit by the storm. The local government communication system was heavily impacted by power losses and the allocation of funds to maintain and improve the communication system (Select Bipartisan Committee, 2006b).

The committee investigating the preparation for and response to Hurricane Katrina concluded that FEMA Director Michael Brown ignored the National Response Plan (NRP) at the time, which would have improved the response (Select Bipartisan Committee, 2006b). The NRP was recently established in late 2004 to reduce the response timing of relief to disaster victims. Michal Brown proceeded in the same process as in past disasters, with concerns about situational information being communicated to the correct agencies. Also, the government at multiple levels could not effectively handle the emergency due to lack of communicating and leadership (Select

Bipartisan Committee, 2006b).

Communication is Conveyed

After a significant emergency has affected a community, it is essential to communicate kindness to help others affected by the disaster. Just-in-time learning from media is essential for those outside the affected area to see the need and support the affected people (Brame, 2024). Just-in-time learning is to find complex answers with active learning with outside-the-classroom information that is utilized to make decisions quickly with outside information from various sources in the midst of a disaster (Brame, 2024). Just-in-time learning can be spread globally once communication systems are connected after a disaster has hit an affected area. Local wireline, wireless, or satellite communication systems can provide service. Once the media has been published, various communication outlets can pick up the story for viewers to see and respond to the news. The information communicated can be valuable to those affected who are seeking local shelter and help to rebuild. Media can also provide experts' viewpoints that may benefit others affected (Browning et al., 2010). However, lack of communication in the area hinders the media’s ability to produce content that informs and supports those affected by, as well as those assisting with, a disaster (Browning et al., 2010).

Communications involve Karl Weick’s theory of organizing, which is adjusting attitude after the event has happened, how people see media, enacting talking about the disaster, selecting visual media to show the disaster, and retaining the information to react and help others in the disaster (Browning et al., 2010). Hearing a story of someone needing help is a powerful way to motivate people. Being able to see the disaster reported in the media will move citizens to make a donation or volunteer to help people affected by the disaster. The communication provided by wireline, wireless, and satellite services helps with the media’s reporting of the disaster

(Browning et al., 2010).

Communication can come in many forms. One consideration in communication is to understand how humans respond to emergency communication. Someone who receives repeated communication of a warning with little information will react less intensely to the situation than someone with a brief, clear, and to-the-point warning for the area they are currently located in (Zhao et al., 2019). For example, citizens who have been in tornadoes or live in or around tornado-prone areas are associated with the “risk as feelings” model; depending on the current weather temperatures changing drastically, the sky is an unusual color, or even animals acting differently (Zhao et al., 2019). One hypothesis was that the risk perception and behavioral response escalated with weather reports. Another hypothesis evaluated the behavior response of seeking shelter in a tornado based on the communication they have receive and process the information (Zhao et al., 2019).

The study evaluated the indirect exposure to the 2013 Moore tornado before and after the exposure of the subsidiary tornado (Zhao et al., 2019). The study shows that people at a higher risk level in the affected area will seek shelter more often than those who are not, and media exposure impacts the behavior. The study did conclude that demographic variables did not affect one's behavior. One study limitation is that the researchers used videos and role-play of tornadoes instead of the real effects of experiencing a tornado. The report presented that seeking shelter and actual shelter-seeking behavior are different. The study did not mention if the participants had ever personally been affected by a tornado in their lifetime, which could affect how they may react sooner or later with communication of a tornado in the area (Zhao et al., 2019).

Communication may come for an evacuation in plenty of time to escape the incoming disaster. However, the impact of leaving pets behind and the lack of pet-friendly shelters is another concern for citizens who may be affected by incoming disasters (Douglas et al., 2019). In 2017, 35% of the Miami-Dade area population had a pet to consider if a hurricane were to affect the area. With the demographic of older adults in the Miami-Dade area, pets are considered a lifeline to reduce loneliness, and thus older adults are less likely to leave a pet behind during a disaster. The study looked at Geographic Information System (GIS) mapping is used to consider older populations in the area and pet-friendly shelters (Douglas et al., 2019). The study also helps improve older adults' communication and emergency evacuation strategies. The results showed that during congested traffic, the average person had to be in traffic for 13.85 minutes, which is a difference from nearby Broward County with 12.82 to go to any pet-friendly shelter. The data was evaluated between American Red Cross shelters, non-American Red Cross shelters and all shelters to see the distance to a shelter in a disaster in Miami-Dade that was pet-friendly. The data that was collected showed that 13.85 minutes in traffic is driving to the main road in the Miami-Dade area. This could be a lifetime for an older adult with a pet in the vehicle (Douglas et al., 2019). Also, if older adults no longer drive, they may have to consider public transportation or hiring someone to drive them to the location, which could add additional strain on someone living on a strict budget. Another concern is that after arriving at the shelter, it may be filled to capacity, and you may have to travel further to another shelter, which can become an issue with fuel shortage in the area (Douglas et al., 2019).

Analyzing data on disruptions in communication infrastructure can come in various forms, from reports to social media posts. The study's data were divided into three classifications based on whether the disruption had a positive, negative, or neutral effect on social media (Roy et al., 2020). Positive disruption encompassed the person posting that the infrastructure did better than they thought with service in the affected area. Neutral is a disruption in a general format, and a negative disruption affects being attributed to the disruption. The data from the research came from Twitter at the time of collection (Roy et al., 2020). The data were collected from Hurricanes Irma in 2017 and Michael in 2018. The data from Twitter were collected into a disruption identification module to determine what type of data and whether the data were related. If the data are hurricane-related, then evaluate if the coordinates of the tweet are in the affected area. If the coordinates were unavailable, dig deeper with a Geo-coding module to see if the coordinates and location in the affected area could be found. Once the data is collected during and after the two hurricanes, they make a disruption map of the data to see the affected areas that lack basic services, including communication. The disruption map will help show each negative, positive, and neutral data classification. The Twitter data was put into the RAKEL technique to label the subset to solve the overfitting problem for analysis. The disruption map is a diverse method of identifying infrastructure disruptions using social media data (Roy et al., 2020).

Supplementary Options

The TED Talk conveys why communication is vital to help coordinate, communicate, and save lives (Stephens, 2018). Show it is important to understand what communication works and does not work in a large-scale disaster emergency to improve communications in future disasters. Understanding how communication has evolved from analog to digital signals of communications that are used in a large-scale emergency is necessary for the wireless communication industry. Unfortunately, 911 cannot get to everyone, making it necessary to look at other avenues of communication for help, such as various social media platforms. With information at your fingertips, teams with walkie-talkies utilizing a two-way radio and map application that is on a smartphone. Breaking down communication barriers using common avenues between government agencies and local community groups can help in a disaster. This strategy addresses intermobility, which affects government agencies when they are not on the same communication system as local community groups (Stephens, 2018).

Exploring other communication options, even with the lack of an intermobility system, can impact how communication saves lives and the perceived lack of concern. Whether it is having two people sit beside each other with both systems or utilizing another communication technology to communicate successfully during a large-scale emergency, considering alternatives is important. Bringing in cultural community groups when considering these options allows for all voices to be heard and understood. Ultimately, people affected by disasters need help after the disaster in cleaning up, providing supplies, and coordinating outside help, which often requires community support from volunteers (Stephens, 2018). Thus, having effective communication systems is crucial.

In the past, emergency communication was processed in a traditional way, using newspapers, television, or the radio, which is one-way communication. With social media added to emergency communication, a new way of communicating is a two-way process to help during an emergency. With social media, citizens help provide information about the situation and what is needed in the affected area. In the past, communications were sent out about what was needed without the additional details that we have today, which assist in the emergency response process. Also, social media helps with necessities not considered a true emergency, such as calling the 911 system (Houston et al., 2015).

The research article looked at social media and information provided to citizens, including preparedness for what to do in a disaster, warnings, how to document during the disaster, and how to connect to community resources after the disaster (Houston et al., 2015). Due to citizens having less connection to past communications, social media can be used to signal a disaster in the area. Communication can also come from citizens alerting government agencies to emergencies from social media, such as an earthquake or civil unrest in the area. Social media data moves quicker to citizens, which in turn gives a quicker response from government agencies and other citizens in the area who can assist quickly. Agencies can also use the data to find the heavily affected areas and dispatch the needed services to the area, assisting the locals affected by the disaster. Services might include providing chainsaws needed to cut trees to clear a path on roads or ensuring there is sufficient blood at the local hospitals (Houston et al., 2015).

One concern about utilizing social media is that two-way communication can also cause division due to viewpoints given, which could be influenced by political or religious issues. After an emergency has happened, social media can also connect friends and family who have been displaced to other areas. During Hurricane Katrina, Facebook connected people of New Orleans with family, friends, and people in their neighborhood (Houston et al., 2015). Several avenues of social media platforms are used in an emergency to communicate with the public, family, and friends. X (formally Twitter) started to be used in 2007 due to wildfires in San Diego, California and is heavily used in emergency communications due to data categorizing (Imran et al., 2015). Social media monitoring has become the norm for many local agencies nationwide. The concern at the federal government level is that research by the U.S. Congressional Research Service shows that adopting social media during emergencies would be costly to the federal government (Imran et al., 2015). The benefit is that time-critical data is being provided on social media to facilitate discussions and communicate effectively with the local area. One benefit from a local public standpoint is the creativity of problem-solving in real-time; for example, social media is utilized to help neighbors find someone to cut trees or clear a path or provide information on where to find supplies in the area after an emergency (Imran et al., 2015).

One of the concerns is the increase in data coming in soon after a significant emergency, which is necessary to make critical decisions. Artificial Intelligence for Disaster Response (AIDR) allows the blending of human information with AI to classify messages from various platforms and categorize the data based on keywords, hashtags, and language. The data can then flow to the correct agencies to help the impacted area with their immediate need. The data can be collected at the time of the event, sent geographically to indicate whether it is in the area, and include the needs expressed in social media posts (Imran et al., 2014). Knowing the language to communicate correctly in the area is vital for efficient human interaction. During an emergency, citizens may become confused or not understand if English is their second language due to stress from the emergency. Having an understanding of the local dialect is critical when gathering the correct information to support the area in a disaster (Nieves, 2019).

The information gathered by AIDR can also be used for education and training for future emergencies based on information gathered from past emergencies using AIDR (Imran et al., 2015). AIDR is primarily used with X (formally Twitter) and was successfully used in the 2013 Pakistan earthquake (Imran et al., 2014). X (formally Twitter) is beneficial due to its crisis mapping, whereby message geotags are utilized to pinpoint the significant need in an emergency. Using the data, spatial zones are discovered to help with the recovery of the area. Data from social media can cause information to cascade rapidly through multiple networks to reach the community when there is an urgent need. Social media platforms have an application programming interface (API), which would benefit agencies by collecting real-time data feeds to rapidly make decisions to assist the affected area. New Event Detection (NED) is beneficial with the continuous evolution of the technology continent, with new emergencies being detected on social media platforms (Imran et al., 2015).

Two challenges emerge with social media in massive emergencies: scalability and content (Imran et al., 2015). Scalability issues are due to the influx of mounds of data at a rapid rate; as an example of an F5 tornado that has hit the area, the data would have a high increase. The second issue is content, as information can be lacking or misspelled in the brief message being sent out. If the data are being categorized, then misspellings of keywords would have to be considered, as well as if there is more than one language spoken in the area to understand the dialect of the area being affected. An example of a social media content issue is a communication posted “Fire in Paris.” Is the fire in Paris, France, or Paris, TN? The additional geographic categories would need to be evaluated to provide better spatial information about the data’s origins and to assist agencies in supporting the local community. Whether an emergency situation is a predicted or unexpected emergency also impacts communication challenges. Another challenge to consider is noise from prioritizing other emergencies, such as a minor rear-end car accident, which could overshadow more critical situations like a wildfire over several acres of land that is affecting homes (Imran et al., 2015).

Categorizing data by utilizing algorithms is beneficial in catching the various misspellings of words, languages being used, and possible local slang that could be communicated on social media (Imran et al., 2015). Another benefit is the ability to use a text-based representation of the emergency with core documents to help citizens in the area and reduce the noise of complex information about the emergency. In the future, social media, AI developers, and emergency management may consider utilizing decision-support capabilities to help citizens with information, considering the best ways to present this information (Imran et al., 2015). Volunteered geographic information (VGI) is beneficial in an emergency; it gathers data to locate debris and flooding after the disaster (Lowrie et al., 2022). The technology comes from volunteers using mobile applications and social media on their phones to alert others of the situation in the area. For example, on the mobile application Waze, it only takes a click to indicate flooding on the road or identify tornado debris in a particular area. This data is collected to help others in the area with reporting and understanding the path of the disaster. The information gathered can benefit future emergency communications, with data processed quickly to help those affected. VGI helps organizations and federal agencies analyze the data quickly to make real-time decisions on the amount of help needed to support the situation. Clustering of reported data helps with the size of the targeted area in an emergency. The Waze mobile application has grown the statistics gathering into the Waze Virtual Emergency Operations Center (VEOC), a community effort to help report real-time data. The mobile application may have been designed to help drive on the road, but it has grown to help with evacuation and reporting large emergencies (Lowrie et al., 2022). One concern with mobile applications is the lack of use in a particular area or population. If flooding occurs in a rural area, mobile applications may be able to process at a normal rate even though a significant emergency affects the rural area. The data are volunteered and are based on users using the mobile application. Reporting could be affected in processing at a slower rate due to the number of volunteers using the mobile application and wireless communication services in the area that is affected by a disaster.

Supplemental communication may also come from other service providers in the affected area (Federal Communications Commission, 2019). Service providers can include competitors in the same industry who work together to provide service. The public notice DA 19-242 highlights the commitment of providers to work together to provide service to the public in declared disasters. The notice includes agreements set in place to work together to provide service to all customers in the affected area of a declared disaster. An example is that AT&T can roam on T-Mobile services if the two organizations agree to allow this option during a declared disaster until AT&T services return. One concern with the mutual agreement is that of reduced service due to the increased number of other customers added from additional wireless organizations (Federal Communications Commission, 2019).

With considerations of the percentage of cell sites down by county, DIRS' main data elements contribute to supplemental communication (Federal Communications Commission, 2019). For example, by requesting the reported information to be broken down further or explaining why the cell site is down, either due to power, fiber to the site, or the site being damaged, contributes to supplemental communication. The agreement is for private organizations and public agencies to provide up-to-date contact information for representatives to be available to state Emergency Operations Center (EOC) inquiries during a declared disaster. Additional information to be requested is information on the framework to be included, such as an example of backup systems, temporary assets, and alternative types of infrastructure. The data will ensure a better understanding of communication services in the area and the effects of the disaster in the affected area (Federal Communications Commission, 2019).

Local government, to recover quickly, is crucial in helping local businesses return to their original state in the area (Masys, 2015). With disaster planning, resilience is a primary piece of engineering for the expected and unexpected, which would come during an emergency. Planning for the unknown with the consideration of regular and irregular threats and unexplained events is necessary. In emergency planning, cracks form a resilience gap for communities that do not consider planning for the unknown. Another aspect is the resilience of helping citizens, which will be gained from sharing responsibility among private entities, government organizations, and citizens. Effectively, shared responsibility will help reduce the resilience gaps in emergency communications related to planning, research, and evaluation by working together. Further, working together will also reduce the resilience gaps. Resilience can be achieved through established procedures for everyone to work with during an emergency and consistent communication when rebuilding the community affected. Having a standard procedure of resilience with communication before, during, and after an emergency will reduce the number of affected citizens who lack communication. Australia has the National Strategy for Disaster Resilience to help with procedures to reduce conflict and confusion in an emergency. The responsibility of recovery is shared with all stakeholders involved. This type of responsibility improves communities, allowing them to rebuild with a stronger foundation to withstand future emergencies and possibly reduce their disastrous effects (Masys, 2015).

The evolution of information and communication technology (ICT) has led to the development of software called Mobile4D, which allows rapid communication between rural and urban areas in the affected area of the country (Ali et al., 2017). The history of the Mobile4D Foundation came from Poverty Reduction and Agriculture Management (PRAM). One of the topics from the program was how to address reoccurring natural disasters, primarily flooding in Laos, which, in turn, led to the development of a mobile disaster alerting and reporting system. Mobile4D helps with reporting, alerting, and sharing knowledge, which is beneficial for agriculture in helping plants and harvest in the area.

The Mobile 4D system is beneficial in the early stages of a disaster, with swift communication to report on the situation (Ali et al., 2017). The system can report on the type and severity of disaster, such as how high the water is in a flood. Then, the system can show a list that categorizes and maps the reported activities. To incentivize rural farmers to get acclimated to using the system, an additional feature is being considered where the current cost to sell agricultural goods is included so that farmers can receive the best offers. One concern is authenticating data from non-authorities in the affected area to be determined as legitimate or not. Also, crowdsourcing from social media does not help with the early warning signs. On the other hand, it does help with reporting the disaster once it has occurred (Ali et al., 2017).

Global Emergency Communications

Emergency communication in Africa faces diverse challenges compared to others due to the lack of interconnected government. Bringing up a viable part that no humanitarian efforts are sent without communication. The absence of a voice means no one is coming to help in an emergency. Africa could experience a war that affects humanitarian efforts in an emergency. The article brings up how communication helps in the media process to outlets outside the continent, which gives mixed messages depending on the information provided to media (Franks, 2010). The lack of communication structure is noticeable in how aid is distributed to those in need in Africa. As a result, one area that may not need help will be provided humanitarian efforts, while another area that needs help may receive little assistance (Franks, 2010).

There is concern about broken communication and miscommunication between aid agencies, the government, and the media (Franks, 2010). Each country and continent have different emergencies to handle, and Africa is no different from handling a war or famine. With structure, their communication in an emergency could improve to help citizens at a much faster rate, which would help people get back on their feet. The concern in Africa is the neglect of communication but offers a little solution to alter the situation. The only media that does come from Africa is from aid agencies that may have their agenda on the communication being guided by others (Franks, 2010).

Canada has a different method to handle emergency communication in a disaster that helps with remote terrain. With 10% of the world’s forests in Canada, a different strategy is utilized for communicating a significant emergency by setting up a Regional Emergency Operations Center (REOC), and communication comes from a regional level. The communication in 2016 about the Fort McMurray wildfire from the REOC expressed the wildfire as not a huge danger. After intensifying communications, the evacuation was broadcasted on local radio stations. The wildfire moved quickly from town to town, and evacuation communication was challenging, as it was difficult to keep up with the swiftness of the wildfire. The wildfire grew from 4 to 150 acres in two hours (Vaillant, 2023). Ultimately, 1,432,635 acres were burned, and 2,400 homes and businesses were lost (Public Safety Canada, 2016). The REOC understands the local area and terrain, which helps them act swiftly in an emergency. The concern is when the emergency, as in the wildfire, becomes more extensive than the REOC can handle and requires additional expertise to handle a grander emergency. Each country has a unique way of handling emergency communication within their country and learning from what has worked best in past emergencies. Learning from other countries on how to handle emergency communications will help save lives in the future (Vaillant, 2023).

Australia brings a unique perspective on disaster risk reduction by utilizing VGI, which strongly emphasizes community engagement (Haworth, 2018). In Australia, the government empowers the community to take responsibility during a disaster in their area. In the affected area, it is not the government's responsibility but that of everyone involved, from the local government, church, and businesses in the affected area. In an Australian study, VGI was used for input on a brushfire risk reduction survey to see how the local community could reduce the risk of brushfires in the area. VGI, in return, assisted in collecting data that could be considered beneficial. It also helped make local citizens aware of the potential brushfires in the area and become engaged in preparation. The community also became closer by connecting with each other to prevent the risk of brushfires in their local area. VGI helps with disaster resilience based on citizens' accurate research (Haworth, 2018).

VGI at a larger scale is a challenge to manage, but for local communities, it is beneficial to see the data and make changes in the midst of a disaster (Haworth, 2018). The limits of VGI are trusting the person volunteering the information and the timing of acquiring the information in a disaster. An example is someone in a brushfire area sharing that they have no issues before the brushfire reaches them compared to after the brushfire reaches their area. The timing of the data should be considered, along with other points of data being provided in the emergency. VGI allows local citizens to be a part of helping the community in an emergency. The community's connection to the local government in Australia helps strengthen disaster resilience, improving communication with everyone involved (Haworth, 2018).

Looking at the effects of social network responses to victims of traumatic events (Saan et al., 2022) categorize several trauma groups in their study, including one for disasters. The countries represented in the study for this particular group is the United States, Mexico, Turkey, Australia, Korea, China, Sri Lanka, Liberia, Sweden, South Africa, Taiwan, and South Korea. The study brings to light the importance of support after being affected by a disaster and considers the supportive, insufficient, or unsupportive responses of others in the lives of those affected. This group can include the local community, neighbors, religious groups, fellow victims, family, and friends. The authors concluded that social networks can play an essential role for victims affected by a disaster. Social networks were recently designed and are growing to find their footing in society as a communication tool. Also, how people communicate can affect how others react to their situation due to a disaster. Pictures, a safe flag, or their writings, for example, could be interpreted differently by those reaching out to help in an emergency. The concern is that the right help won't reach the right victim when utilizing multiple social media networks. Further time, research, and additional information on social network support could lead to it affecting the victim positively or negatively over time (Saan et al., 2022).

Taiwan looks at disasters in three divided aspects: emergency management center, disaster response, and disaster prevention (Chen & Hsu, 2019). Taiwan utilized the basic theory of disaster prevention, which conveys that a disaster is something that can be bought on to cause harm or damage to human life, property, and comfort. Catastrophes can also be categorized into natural and human-made disasters. Another aspect of the definition of a disaster brings in the features of disasters, including regional, timelines, chain reaction, complexity, and accumulation factors. Depending on the feature, an event can be determined as a disaster or not in the affected area (Chen & Hsu, 2019). Taiwan has found the three divided aspects beneficial due to the country's various natural disasters and to accommodate the different types of disasters that affect the country. An example of disaster prevention is debris removal to prevent flooding and to have structures in place for debris flow if it does occur. If a disaster does happen, they have disaster response inclusive of a warning system, depending on the disaster, that includes evacuation and shelter information for the affected citizens. Then, they set up an emergency management center to accommodate the disaster (Chen & Hsu, 2019).

The three aspects are divided even more to accommodate the various levels needed to support each aspect's success (Chen & Hsu, 2019). An example is debris flow: proper equipment reduces debris flow issues, making it less likely that debris, including large fallen tree or fallen rocks, could clog up a waterway flow due to being in the way of debris flow. One issue that Taiwan was having with their process was communication. Knowledge and implementation were also issues that Taiwan experienced during disasters within the country. In 2000, the Disaster Prevention and Response Act was created to help plan, coordinate, and assist in bringing to light imperfect laws and regulations affecting communications at each level in Taiwan (Chen & Hsu, 2019).

DIRS Reporting

The United States started the Disaster Information Reporting System (DIRS), which reports outages from multiple communication providers during a significant disaster (Federal Communications Commission, 2023). The User Guide for this system supports understanding how information is collected, viewed, and downloaded for usage (Federal Communications Commission, 2023). The guide includes roles and capabilities with descriptions. The guide helps the system create, sign, navigate, and report. The system also includes details about companies and users. The DIRS reporting system is helpful enough that if an account user needs to switch from one organization to another, the system is set up to accommodate multiple organizations handled by that user. The DIRS User Guide also generates maps of the affected areas. The data requested from states are the wireline, wireless, broadcast, cable, interconnected VoIP, broadband, and satellite providers in the affected disaster area. Data can be inputted manually in bulk, depending on the organization's need to provide the information. The User Guide gives the particulars that generate, download, report, and upload data (Federal Communications Commission, 2024).

In 2022, the Federal Communication Commission (FCC) developed the wireless network resiliency cooperative framework as part of the Mandatory Disaster Response Initiative (MDRI) (Federal Communications Commission, 2022). This framework mandates all providers to adopt the Resilient Network notice and establish coordinated efforts for roaming agreements to standardize responses. The arrangement is to have agreements in place before the agreement is needed and to test the process to resolve issues before the service is needed in a disaster situation. Lessons from past disasters have helped improve the process and build the framework for current roaming agreements. Each disaster will be evaluated on a case-by-case base due to the nature and location of the disaster. When analyzing the cost-benefit information, the benefit exceeded the cost. Providers have contributed by voluntarily entering into agreements in the past without being bound to terms or before reaching the need to initiate roaming on another provider. A detailed timeline of bilateral compliance is additional information provided by each provider to the FCC (Federal Communications Commission, 2022).

The federal, state, and local governments have initiated the use of short message service (SMS) with warning alerts to make notifications in an emergency (Stephens, 2019). A higher level of communication comes from the federal government with federal wireless emergency alerts (WEA), which have a high priority when processing wireless services in the affected area. The concern with WEA is that users can opt out of the services, which can affect everyone’s ability to receive adequate information in a time of need. WEA has had bumps in the road. As an example, in 2018, a false alarm from WEA was sent out to people in Hawaii that a missile had launched towards them and to seek shelter. It was later stated that the communication was sent in error. On the other hand, the year before, California decided not to use the system during the Sonoma County wildfire that killed 44 people due to the concern of mass exits of the area that would cause additional issues for the public safety working in the area. California was concerned the message would be sent to a larger audience that was not affected by the wildfire and would cause more issues. Since then, the geography of WEA has been improved to show the detailed area that is being affected by an emergency if needed (Stephens, 2019).

Communication of disaster procedures with clear warnings about the situation is critical. The lack of communication and understanding of the situation in Maui, Hawaii, in August of 2023 became apparent to the world (Mittelstaedt, 2023). High winds were experienced in the area, which made locals reluctant to turn the power off due to water pumps in the area needing electricity. In return, close to one hundred lives were lost. The communication breakdown of using text messages instead of warning sirens per policy was an issue considering the disruptive coverage from the weather. Hawaii has one of the largest outdoor siren warning systems. However, it was not used during the wildfire due to the concern that citizens would think it was for a tsunami warning, which it is commonly used for, and not a wildfire evacuation. The reason was that there was a concern that citizens would not be able to tell the difference between a wildfire and a tsunami warning. Text messaging was the best way to communicate with people in the area. Communication and education are essential for everyone involved, acting as their own first responders. In this instance, the challenges could have been better mitigated with better coordination including having a communication structure with an adequate incident-command system earlier utilization of DIRS reporting (Mittelstaedt, 2023).

Risk communication must focus on clear, concise information and additional planning, future use, and future needs (Stephens, 2019). Communication risk needs to be considered to diminish the consequences of future misunderstandings during an emergency. Building trust with all stakeholders and helping communicate with everyone safely in times of need is necessary. Each person handles information differently and should be considered in times of distress, which is considered in the hear-confirm-understand-decide-respond model (Stephens, 2019). The hear-confirm-understand-decide-respond model is when someone hears about an emergency in their area and seek out additional information on how to react to the risk that could or could not affect the person. An example is a childcare provider in the path of a tornado, saving the lives of the children by putting them in a safe, secure area after receiving the alert. If they had hesitated when receiving the alert or did not understand the information that was received, then the children, along with the caregiver, could have been harmed due to not understanding the information provided in the alert (Stephens, 2019). Understanding potential disasters in the area and how to react to the communication benefits everyone involved. Each area of the United States may not have the same emergencies to consider when sending out information. New emergency issues may evolve in the future and need consideration when sending out alerts about. When using the hear-confirm-understand-decide-respond model, it is important to have the correct communication structure (with language considerations) for when a WEA is distributed to the affected area (Stephens, 2019).

The bureaucracy that could affect communication infrastructure has slowed down the utilization of communication infrastructure in the past. With DIRS reporting currently focused on evaluating one-way communication, should a future expansion include two-way communication through social media? Each piece is a concern as significant emergency events occur at an increased level in the United States, along with the increased communication outlets being utilized by citizens.

Chapter III: Methodology

This study utilized public data with the understanding of privacy considerations and utilized public data to answer the research questions (Collmann & Matei, 2016). The viability of data from public information was assessed by examining historical data from DIRS communication reports. The study aimed to investigate if the emergency communications reports supported the impacts on communications to the public and any bureaucratic affected emergency communications during a large-scale natural disaster. Before DIRS, from 1953 to 2005, a total of 1,603 major disaster declarations were requested, with a total of 642 requests being turned down (Rubin, 2012). The 28.6% turndown rate highlighted bureaucracy concerns and the reasoned why communication is important during an emergency (Rubin, 2012). Research questions examined the gathered historical public data to evaluate change over time. The next step was to look at the data process in the research, as well as the security of data during the research process. Finally, the study evaluated the measured variables, including data provided by communication services organizations, that no longer work after a natural disaster has affected the area.

Research Design

This secondary data analyzed measured the pertinent public data within DIRS reports to analyze any change in reporting information to DIRS over time. The secondary data analysis is valuable due to the large scale of the data being evaluated and the access to the information for the study. The data was previously collected from the federal government and thus reliable for the study that was conducted. The data also brought the historical trend of whether DIRS was working and what should be considered for future aspects in the reporting process (Federal Communications Commission, 2024c). The statistical analysis did examine the current viability of the reporting from communication organizations and provided valuable data to the federal government. Attention was paid to possible expansions of DIRS reporting to encompass new applications for benefits in the event of future disasters. The expansion of DIRS was considered due to the fact of how each person handled information differently in times of distress, which has been brought to light with the thought-out in the hear-confirm-understand-decide-respond model (Stephens, 2019). Future technological changes that may expand the reporting of collected data should also be considered.

Purpose of the Study

The purpose of the study was to determine if the DIRS process is viable in today's society and what alternative communication technologies might better provide support in a disaster. This study considered how the federal process impacted communication infrastructure during and after a disaster in ways that could slow down response when timeliness was essential. With the changing communication technology over the last 19 years, including the introduction of smartphones, applications, and alternative technology, DIRS could be expanded to accommodate the change and grow with society. The communication infrastructure is affected by how the government processes information and distributes it to affected areas, as well as how other stakeholders use this information after a disaster.

With the significant technological changes in utilizing GPS data, other applications are processing ground-level changes in the area, and methods are providing cellular signal strength in the smartphone area. The research studied the expansion of DIRS reporting could be beneficial with real-time data to make accurate decisions in the midst of a disaster instead of delaying information reporting. Considering the bureaucratic concern, the data to be examined is the historical data of Disaster Declarations by states and the type of disaster considered for

DIRS reporting to see the impact before, during, or after a disaster.

Research Questions

RQ1: What were the major impacts of communication infrastructure post-disaster since 2000?

RQ2: How do bureaucratic issues impact communication infrastructure before, during, and post-disaster?

RQ3: What is the prospect for sustainability of the Disaster Information Reporting System (DIRS)?

RQ4: What potential changes might benefit the Disaster Information Reporting System (DIRS)?

Historical Data

Data was sampled from past DIRS reports on previous disasters from 2016 to 2023, to evaluate change over time. The analysis identified whether there was an increase, plateau, or decrease in the data provided by the communication sector during a disaster in the United States. A limitation was that data from DIRS was potentially missing. The information was voluntarily provided by various communication organizations in the United States. However, these organizations might have submitted inaccurate data to appear favorable to the federal government, suggesting fewer issues in the disaster area. Within the data, there were notations of data being updated after the report is submitted. Another limitation was that the timing of the data being evaluated by the organization and then submitted could be delayed. This affected the accuracy of the data being reflected, due to the lag in data processing and reporting by the federal government. The data is provided once a day to the federal government and is a snapshot of the service being provided at the time of collecting data. Another limitation is whether communication services can be processed accurately at the time of looking at the data but be down the next 23 hours after the data is gathered.

Description of Data Collection Process

The data used was official DIRS information from the federal government. The information was used to analyze current data reported by various communication organizations in the United States during a disaster. The information can be accessed on the FCC public webpage. The role of the federal government in an emergency is to understand the status of communication in the area of the disaster. The data provided benefitted emergency management in the communities affected. As a public record of the Federal Communications Commission (FCC), past DIRS reports of each day are available by disaster and then dated at FCC website in the past response efforts. The data from 2016-2023 was total responses, with a communication report for each date of the responses. The data list included counties affected by the emergency, Emergency 911 services affected, wireless services, cable systems/wireline (combined), broadcast television, and radio. Lastly, any special temporary authority waivers, or extensions that were given during the disaster were reported.

The data for wireless communications included the most detail in the reports with cell sites served, cell sites out of service, cell sites out due to transport or power, and cell sites up but on backup power. Percentage out was also calculated utilizing the data from cell sites served and out in the affected county. Services for 911 listed out the affected locations. The cable systems and wireline (combined) brought to light the number of subscribers out of service, and the number was a total combination of wireline telephone, television, and internet services. Lastly, the report included broadcast television and radio, and it lists the number of television AM or FM radio stations based on the station type and the name of the station. The communication report from each day of the response will be downloaded to process the data (Federal Communications Commission, 2024c).

Similarly, assembly data from the Federal Emergency Management Agency (FEMA) showed the ratio of Disaster Declarations during the same time period and the number of disasters that activate DIRS (Federal Emergency Management Agency, 2024b). The data also demonstrated which states had a higher impacted on disasters during 2016 to 2024.

Data Security

The study utilized public domain information, which is public record data maintained by the federal government. Data security followed the federal government's public data security process, which is open record data for viewing on the FCC website. The data was anonymized with no personally identifiable information to protect privacy if and when it is needed. Communications Status Reports were downloaded and stored in a secure private cloud during the process of gathering data from the federal government data website.

Variables in the Study

The measured variables included data provided by organizations on communication services that no longer work after a natural disaster has affected the area. The study's independent variable is the damage to the communication structure of a large-scale natural disaster in an affected community. The study's dependent variable was the work completed to restore service to the affective community after a large-scale disaster. Another variable to consider was the extraneous variable of weather, depending on the scale of the weather event and location, which could affect the independent and dependent variables of the data.

Once collected, the mean for each response and the overall mean were determined to see the average. Once the mean was evaluated, the median for each response and the overall median of data collected from the communication report were evaluated. Finally, the mode of each response, as well as the overall data from the communication provided by the FCC, was evaluated.

Chapter IV: Findings and Analysis

Procedures for Data Analysis

The data was gathered from the Communications Status Reports for each disaster the Federal Communications Commission handled. The report was a daily report gathered on the status of communications by each broadcasting group in the United States and territories during restoration efforts after an emergency; for additional detail, see Appendix A. The data used was gathered from individual daily public reports from the federal government and then transferred to into a separate document for review. The data was formatted into usable data for each type of broadcasting to find impacts of communication infrastructure post-disaster. Gather data to find where improvements in the DIRS could benefit in the future. Along with considering the bureaucracy of DIRS affecting the data.

Cleaning and Preparation of Data

In the DIRS reporting, a small number of reports had been updated, and the original reports were posted for the same day. The updated communication report data was utilized in the gathered data rather than the original report. The one report for tropical storm Henri was inaccessible, and we could not receive data for the report. Hurricane Maria had two communications reports that were not accessible due to the FCC webpage for the dates October 10, 2018, and December 15, 2017. Also not considered were the six reports for Winter Storm Uri in 2021 due to the Communications Reports not following the same standard format of data gathering as all of the other Communication Reports.

Any errors in the reports' data were left intact due to public record data, which made it impossible to verify the accuracy of the data. For example, on one report, the county would say there are 69 cell sites in the county, and the next day, it would report 96 cell sites in the county.

The data was formatted to be standardized as the reports slightly changed over the years, and the details were reported to the federal government.

Data Analysis and Modeling

With a standard layout of 27,575 data points of 37 reported disasters, the mean, median, and mode of each type of broadcasting communication were found. The range, minimum, and maximum aways were also gathered to examine each broadcasting communication service's outlier values while seeing the data's spread. The data was gathered in Excel and stored in one document instead of multiple communication reports. Each of the five types of communication in the DIRS report was on individual tabs to gather the data. Once gathered from each report from the FCC webpage, the data was organized into common data points. There were communication reports that had additional information that was gathered or in a different format that was also evaluated but was considered outlier information since it was not consistent in the reports to show value for the research. Once all data was put into a standard format, the mean, median, mode, range, minimum, maximum, and sum were calculated using descriptive statistics in Excel. Table 1 represents the overall number of the five communication systems reported into DIRS. Table 1 shows the mean, median, mode, range, minimum, maximum, and sum of each type of communication system being reported. Then, due to the extensive effect that Hurricane Maria had with 106 communication reports compared to the second-highest coming in with 30 communication reports with Hurricane Irma.

Table 1

Results of DIRS with and without Hurricane Maria

	PSAP		Television		Radio		Wireless Communication		Cable Systems and Wireline Service	
	With	Without	With	Without	With	Without	With	Without	With	Without
Mean	0.13	0.11	0.57	0.67	1.02	1.07	9.27	5.94	166,784.14	219,400.56
Median	0	0	1	1	1	1	2	0	16,700	53,646.5
Mode	0	0	1	1	1	1	0	0	0	0
Range	1	1	6	6	21	21	1,019	1,019	8,258,789	8,258,789
Minimum	0	0	0	0	0	0	0	0	0	0
Maximum	1	1	6	6	21	21	1,019	1,019	8,258,789	8,258,789
Sum	49	34	299	267	4,745	1,711	200,044	78,178	73,718,588	73,718,588
Count	392	286	523	399	4,640	1,595	21,578	13,153	442	336

Assessment with Data Collection

With the impairment impact of communications infrastructure post-disaster of Hurricane Katrina since 2005, the Public Safety Answering Point (PSAP) being out of service was not gathered before 2016. The data from 2016 to 2024 shows that reporting and tracking the outages during the recovery after declared data shows a slight number of reported outages. Only seven weather events showed an outage; five disasters had less than five reported outages for the entire event. Two events had a high reporting number: Hurricane Irma, with 15, and Hurricane Maria, with 21 total.

Television and Radio Stations

Television stations, since reporting started in 2016, the effect has shown a decrease in reported outages, with Hurricane Irma having the most reported outages, with a decrease since 2017. Twenty-one disasters did not have an outage reported. Table 2 brings into perspective the results of the number of television stations out of service within each communication report by year. The increase in 2017 is due to Hurricane Maria, which was reported in the last quarter of 2017.

Table 2

Results of DIRS with the Number of Television Stations Out of Service by Year for each reported disaster.

Year	Count
2016	5
2017	112
2018	63
2019	4
2020	25
2021	31
2022	26
2023	31
2024	2

Radio Stations, on the other hand, have fluctuated from the communications reports, possibly due to the disaster's location and the storm's strength. With Hurricane Maria, a total of 3,034 radio station outages were reported in 106 reports. The same 46 radio stations are often reported as out of service each day. In many communications reports, the same radio stations were affected each day of the disaster, which may indicate that the station shut down for personnel safety or was damaged. Table 3 shows the results of the number of radio stations out of service within each communication report by year. The increase in 2017 is due to Hurricane Maria, the effects of which were reported in September, October, November, and December.

Table 3

Results of DIRS with the Number of Radio Stations Out of Service by Year for each reported disaster.

Year	Count
2016	118
2017	3,367
2018	383
2019	53
2020	331
2021	117
2022	189
2023	119
2024	112

Cable systems and wireline services

Cable Systems and Wireline services provide a different aspect of the figures in the communication reports by giving the number of customers affected each day of the disaster. The sum below is the total of each disaster. Similar to radio stations, the number fluctuates depending on the disaster's location and the system's infrastructure in the area. Table 4 brings the total number of customers affected each year by cable systems and wireline out of service. The number is affected by location and number of reported disasters for the year.

Table 4

Results of DIRS with the Number of Cable Systems and Wireline Customers Out of Service Year for each reported disaster.

by Hurricane

Year	Count
2016	1,344,951
2017	38,469,928
2018	4,397,252
2019	1,917,139
2020	6,300,325
2021	4,970,123
2022	11,669,839
2023	487,569
2024	4,161,463

Wireless communication

Wireless communication sites have decreased since 2022, even with the increase of cell sites being built across the United States. Data provided has also changed over time, starting in July 2019, with the addition of breaking down the sites out of service due to damage, transport to the cell site out of service, and power out at the cell site. In some disasters, additional data of cell sites on backup power and portable assets being accounted for was also communicated in the reports but not consistent with the reports. Table 5 shows the number of wireless communication sites out of service by the year reported in a disaster. Depending on the number of reported disasters, the location of the affected area, and the duration of the reported disasters affected, the count is shown below.

Table 5

Results of DIRS with the Number of Wireless Communication Sites Out of Service by Year for each reported disaster.

Year	Count
2016	341
2017	9,627
2018	1,029
2019	820
2020	4,284
2021	1,083
2022	2,157
2023	237
2024	658

This research question examined the bureaucratic issues impacting the communications infrastructure before, during, and post-disaster. The reporting process occurs once a day, and the only communication avenues examined were available from 2005. Since 2005, communication has evolved with additional avenues that use wireless communications services with applications, text message processing, types of cell sites, and services running over wireless services. On the other hand, wireline and cable services usage has decreased over the last few years, with fewer people using the services provided.

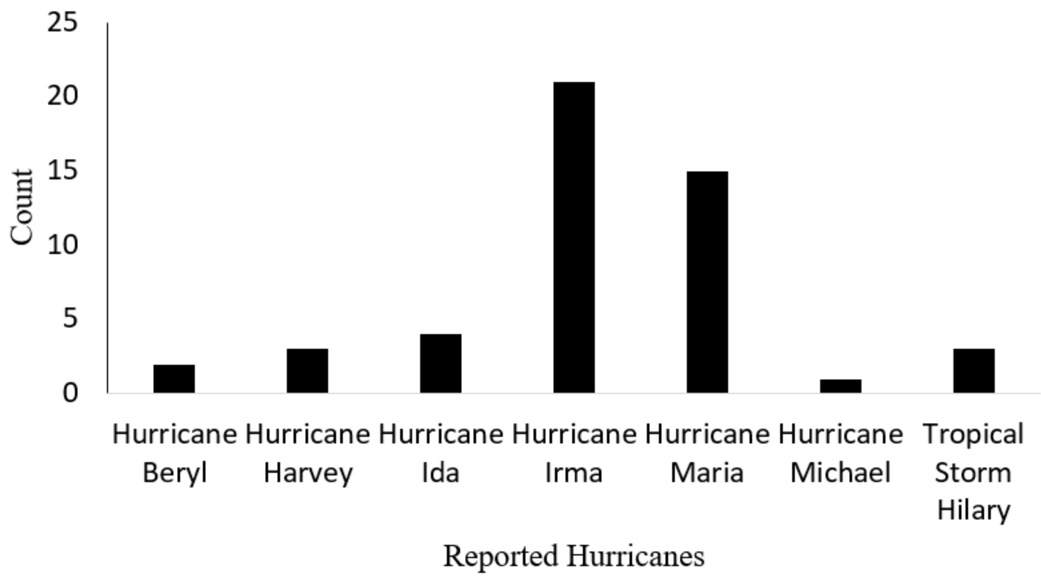
The future viability of the Disaster Information Reporting System (DIRS) needs to change and adapt to the time of disaster communications landscape. Water treatment must have essential communication services to provide water services for the area even after a disaster. GPS is used to process the location of someone who calls 911 for help after a disaster has hit the area. The possible improvements and expansions that might benefit the Disaster Information Reporting System (DIRS) include what service is helpful after a disaster, depending on the country's area and the disaster. Evaluating new communication services, including satellite services and future technology.

Statistical findings of DIRS

Of the 37 disasters, only seven had PSAP issues, as shown below, along with the total amount reported on each report. Figure 1 displays the number of PSAP locations out of service by disaster which shows the reporting being affective for the decrease in reported outages..

Figure 1

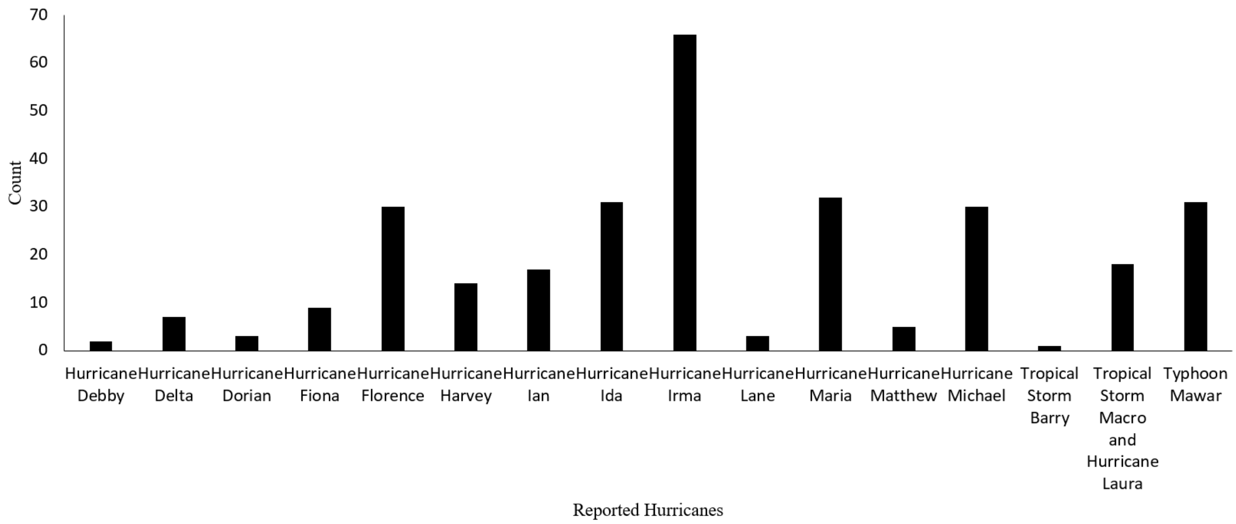
The Sum of Affected of Public Safety Answering Point (PSAP) reported in DIRS



Television stations were involved in 37 of the reported disasters, and 16 of the disasters reported issues with television stations' broadcasting. Below is the total amount reported on each report. Figure 2 displays the number of television stations affected by the reported disaster in DIRS.

Figure 2

The Sum of Affected of Television Stations reported in DIRS



Radio stations were involved in 37 of the reported disasters, and 29 of the disasters reported issues with radio stations' broadcasting. Below is the total amount reported on each report in Figure 3 of radio stations out of service by disaster.

Figure 3

The sum of affected radio stations was reported in DIRS

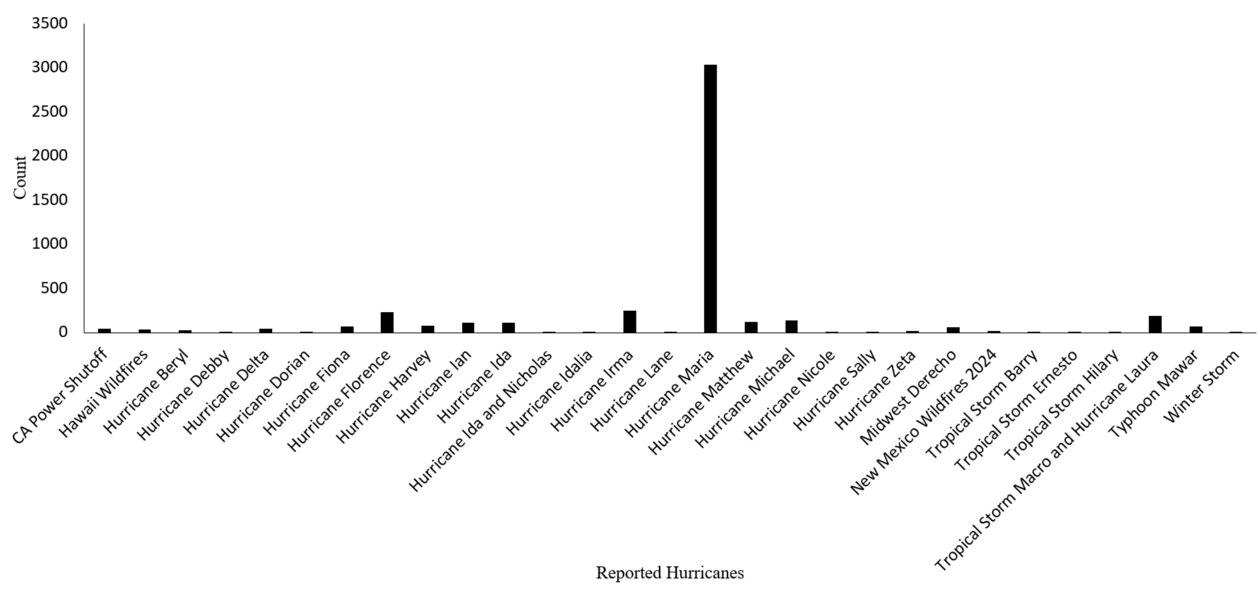


Figure 4 illustrates the number of radio stations out of service by disaster, not including Hurricane Maria. Due to the large volume of communication reports, the number of communications reports for Hurricane Maria is considered irregular compared to other reported disasters.

Figure 4

The Sum of Affected Radio Stations reported in DIRS, not including Hurricane Maria

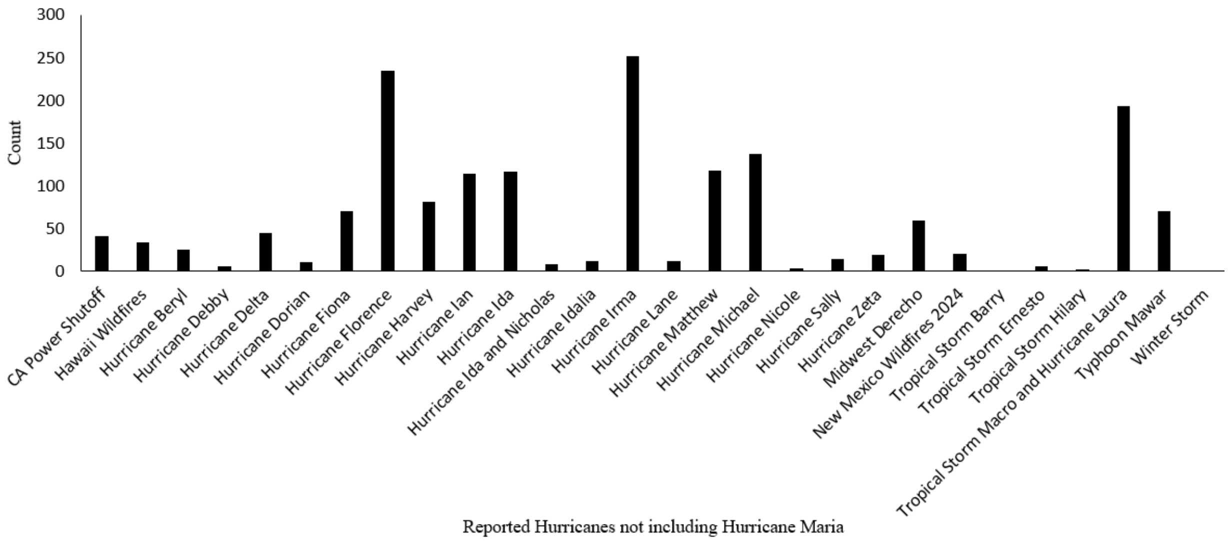


Figure 5 shows that only 36 issues for cable systems and wireline data are reported below. Cable Systems and Wireline reporting in DIRS is based on customers impacted. Hurricane Maria was not reported due to its size, so the numbers could not be calculated.

Figure 5

The Sum of Affected by Cable Systems and Wireline reported in DIRS

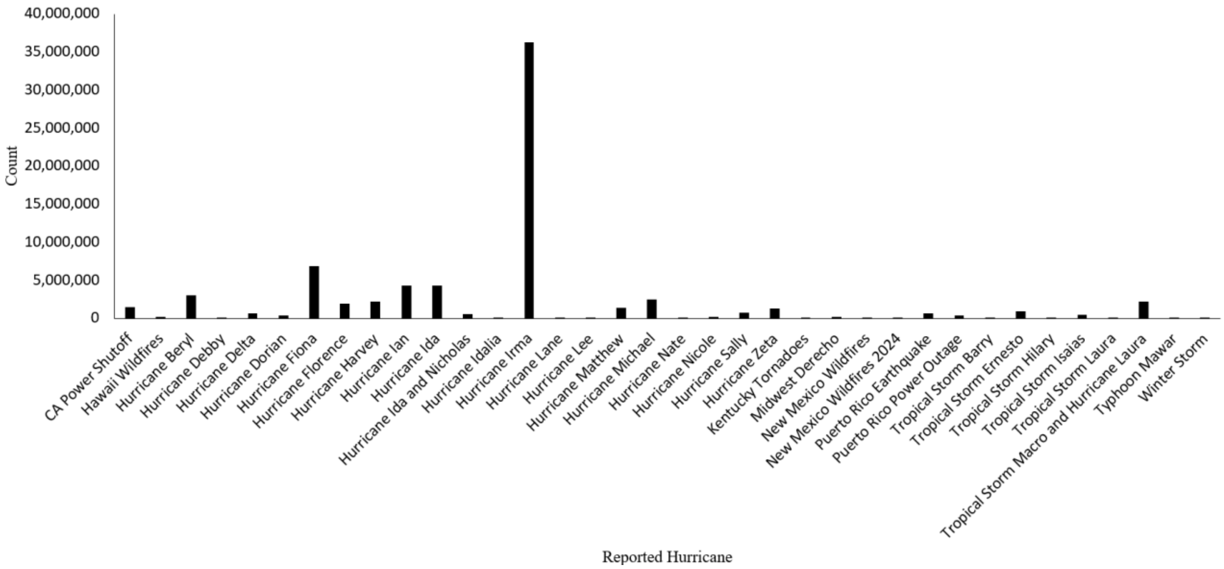
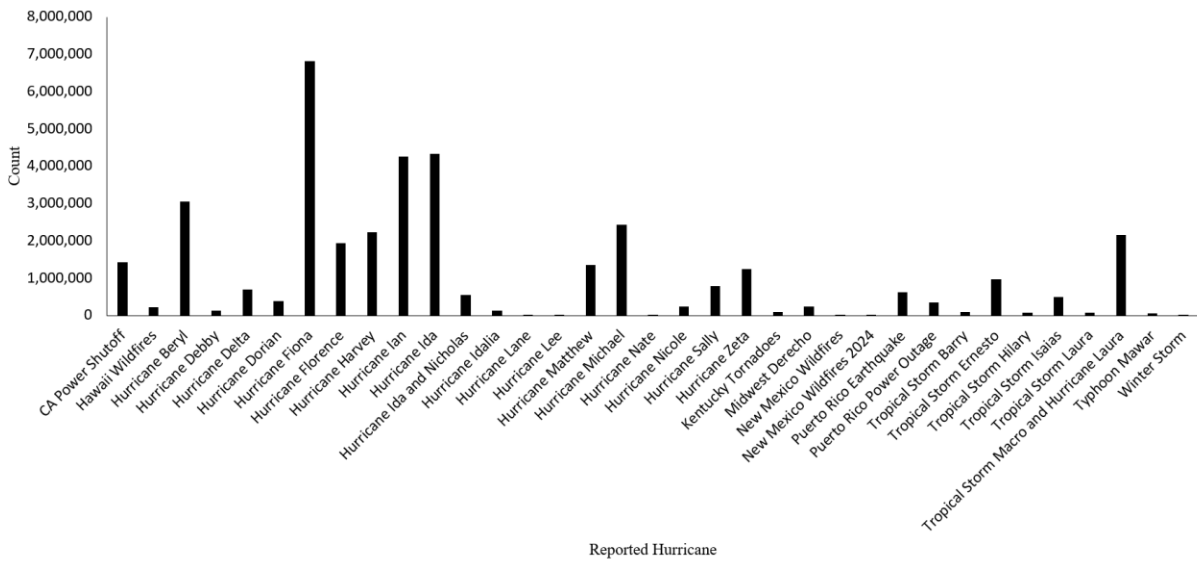


Figure 6 shows the number of cable systems and wireline customers affected by reported disasters not including Hurricane Irma, which is considered an anomaly compared to other reported disasters due to the large volume of customers reported as not having service for Hurricane Irma.

Figure 6

The Sum of Affected by Cable Systems and Wireline reported in DIRS not including Hurricane Irma



Wireless communication services were reported for each disaster, with Hurricane Maria reporting the most cell sites out of service due to the length of time of the reports and the devastation of the hurricane in Puerto Rico. Figure 7 demonstrates the number of affected wireless communication sites that were out of service by the disaster. Due to the large number of reports generated over several months for Hurricane Maria, other reported disasters are small compared.

Figure 7

The Sum of Affected of Wireless Communication reported in DIRS

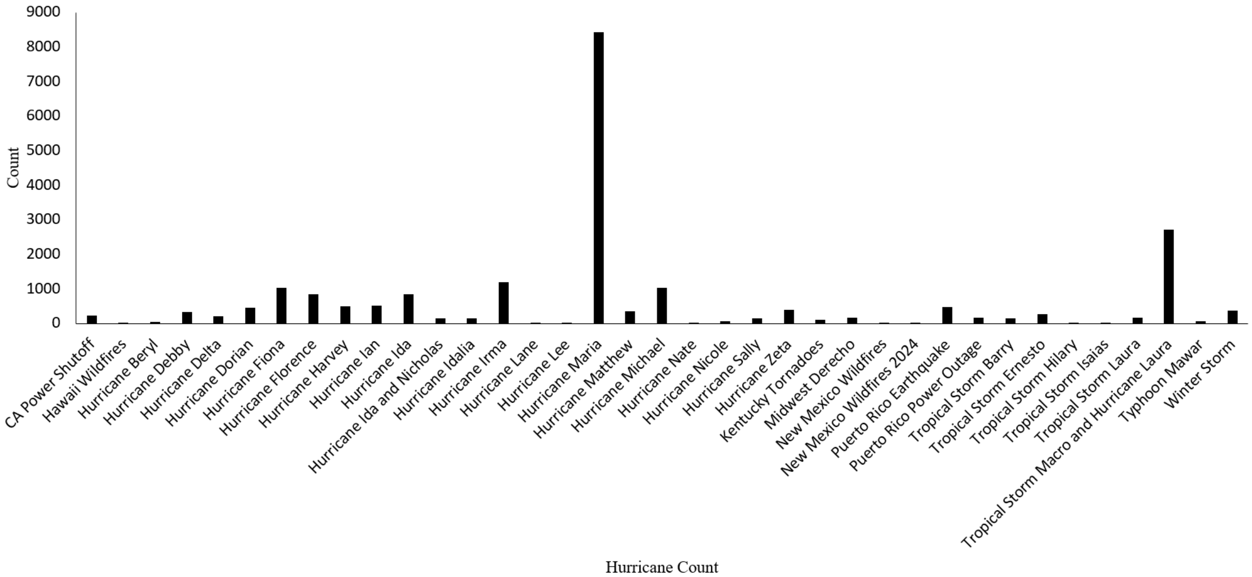
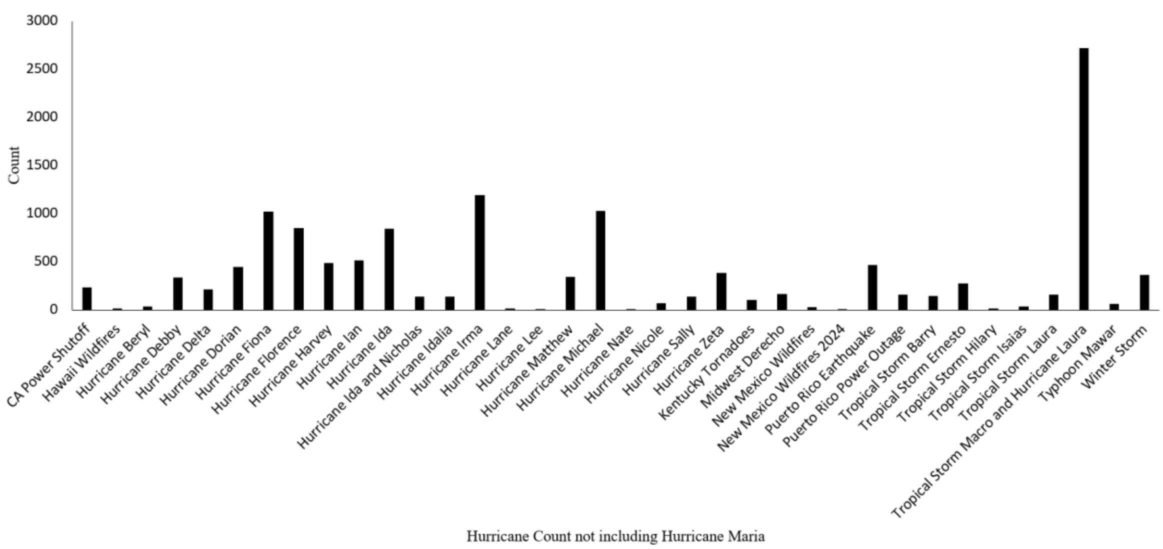


Figure 8 shows the number of wireless communication sites out of service by disaster, not including Hurricane Maria, which is considered an anomaly compared to other reported disasters due to the large volume of communication reports for Hurricane Maria.

Figure 8

The Sum of Affected of Wireless Communication reported in DIRS, not including Hurricane Maria



Chapter V: Discussion and Conclusions

Summary of study

This study includes the five aspects of communication reported to the FCC during recovery post-disaster: public safety answering point (PSAP), wireline and cable systems, radio, television, and wireless cell sites. In conclusion, the research evaluates each question independently, starting with the first question to be evaluated.

RQ1: What were the major impacts of communication infrastructure post-disaster since 2000?

The study findings indicate that some aspects of communications post-disaster have improved, primarily in PSAP. An example is the small amount of PSAP reported as out of service in DIRS. The results exposed that 81 percent of disaster reports had a functional PSAP or rerouting to another location. On the other hand, other communication avenues, such as wireline and cable systems, have less impact due to customers moving to new technology (Vogelsang, 2010). The reality of infrastructure post-disaster is that every disaster differs by location, type, or size, and communication is affected by each aspect. One disaster may have one report listed for the disaster, while another could have 106 communication reports. The improvement of the five reported aspects of communication needs to be constantly evaluated to see if future technology can impact these various aspects of communication.

RQ2: How do bureaucratic issues impact communication infrastructure before, during, and post-disaster?

Bureaucracy impacts reporting on the communications infrastructure before, during, and post-disaster. With each step, there is the concern for delays caused by bureaucracy. Other avenues of broadcasting services needed to be considered after Hurricane Katrina in 2005. The federal government is slow to keep adapt to the fast-paced change of technology. The increase in reporting should include new technology and possibly reduce technology that is not being used by those in the area affected by a disaster. Also, the negative impact on communication infrastructure could be reduced by burying communication infrastructure or strengthening towers in areas heavily affected by disasters.

RQ3: What is the prospect for sustainability of the Disaster Information Reporting System (DIRS)?

The future viability of the Disaster Information Reporting System (DIRS) is dependent on its ability to evolve by considering new technology in the communications and broadcasting fields. Understanding what services citizens currently use to provide up-to-date communications and how they desire to be communicated with is critical for developing effective emergency communications planning. After eight years of data, it may be time to revamp the communications process. Currently, the lack of communication services for citizens impacted by Hurricane Helene may agree that the ability to call for help and receive updated information is essential (Wile, 2024). Future technologies should be considered as potential types of satellite services accessible in the area, with a comprehensive assessment of the needs and infrastructure capabilities of the local area being affected. The future of emergency communication includes providing other avenues of new technologies, such as unmanned aerial vehicles (UAV).

RQ4: What potential changes might benefit the Disaster Information Reporting System (DIRS)?

Possible changes that might benefit the Disaster Information Reporting System (DIRS) include what service is helpful after a disaster, depending on both the geographic area and the disaster. Hurricanes Helena and Milton show that communications before, during, and after a major storm are already changing (Wile, 2024). The possible improvements would be to demonstrate the reporting of new technology within the existing communications services being reported. Provide tangible data to support incorporating innovative communication technology.

Incorporating the latest technology communication service providers into the DIRS reporting framework will enhance the system's reporting capabilities. The expansions of other providers, such as Starlink, which provides satellite communications being incorporated into DIRS, will strengthen the process and bring communications from other avenues not currently being reported to light.

Conclusions

DIRS reporting from Hurricane Katrina has improved communication infrastructure by highlighting how important communication is to affected citizens recovering from a disaster. The reporting brings insight into the areas that need improvement to one of the significant infrastructures during a disaster. The availability of post-disaster communications is vital to providing help, informational resources, and a process of knowing what to do next after the disaster. Bureaucracy has affected aspects of the communication infrastructure, and improvements should be considered for future reporting of disasters. The future of DIRS is to grow by considering new avenues of technology and reducing reporting on communication systems that are outdated. One improvement that might benefit DIRS includes gathering similar data for each type of technology. For example, the wireless service provider is presented in the DIRS communications report by the county, in which none of the other communications are broken down in this manner. The rest of the communication types are either broken down by the individual name of the station or by the number of customers being affected. Population counts of the affected area would be beneficial to know how many people are affected due to the lack of communication services. Consider applying a similar format for each type of communication infrastructure being reported in the communication report to ensure consistency and clearness in the data being presented. Wireless services are in a spreadsheet format, while radio and television are reported in a sentence format. Lastly, consider removing wireline and cable services from the report and adding new technology services existing in that geographic area.

Outside of DIRS how communication is conveyed from a leader in an emergency should create trust in individuals working in the situation. A lack of trust can affect each phase of emergency communication, resulting in uncertainty regarding the accuracy of the information provided and a lack of confidence regarding how a large-scale emergency would be handled. If others trust those around them during an emergency, communication between groups will flow smoother, and the response will be quicker for those in need. Building communication before a disaster happens and having a way to communicate with all parties in a large-scale emergency helps reduce friction between various groups. Having trust and listening to others reduces issues in the future that could prevent further emergency situations or affect additional citizens. Trust in communication will help citizens affected by a significant emergency (Abrashoff, 2012). Conveys another form of leadership that is beneficial to building trust and communication before, during, and after an emergency. Trust helps by breaking down barriers that can get in the way of helping those in need. An example of breaking down the barriers is the communication of a pre-disaster emergency declaration from a state to the federal government. This communication helps reduce barriers to emergency assistance for citizens from the federal government due to natural or human-made emergencies that are predicted to happen. Leadership from state government officials preparing for an emergency helps build trust with the citizens affected by the emergency (Abrashoff, 2012).

In an emergency, it is not merely one individual working, it is a multiteam system between public, local, volunteer, and private agencies (Stephens, 2019). Each agency has a role in the emergency to understand, support, and respect the others working for the common goal to help the affected area after a significant emergency. With experiences of planning and working together in the past, multiteam systems can now successfully accomplish delivering support and resources to the affected area. The structure theory brings in knowledge of how human practices are influenced by structure procedures and resources (Stephens, 2019). The structure theory in an emergency or when someone working or helping out in an emergency is not an individual but part of a larger group of volunteers or support staff that exists within the emergency. Once this is understood, walls are broken down to help find the right resources to quickly support affected communities. The collaboration is beneficial for all stakeholders involved to be successful for the greater good of those affected (Stephens, 2019).

Relationship of Conclusions to Other Research

Emergency communication, evident with the Galveston Hurricane of 1900, has changed over the years from the telegraph to GPS (Rubin, 2012). This change has affected emergency communication, and the historical change to the DIRS has highlighted the importance of emergency communications. Reporting should also change over time by considering new technology, while retiring tracking of older communication systems. The structure of reporting within emergency communication is beneficial for everyone involved in making quick decisions in a timely manner. Reducing bureaucracy, such as with the Disaster Relief Act of 1974 brought together private and federal organizations to improve emergency communication, and again, after the review of Hurricane Katrina (Rubin, 2012). After Hurricane Katrina, the Emergency Communications Division was established to strengthen emergency preparedness communications (Select Bipartisan Committee, 2006b). The change in emergency communications came due to the lack of communication infrastructure during Katrina, which affected many citizens during and after (Buckles, 2022).

The future viability of DIRS depends on various communication methods involving more than five types of communication services, including LINC radios, Satellite phones, and amateur radio operators (Select Bipartisan Committee, 2006b). The improvements of DIRS will come with considering new technology in the process of being patented, and other considerations, such as social media connections (Roy et al., 2020). Social media brings a two-way communication to help citizens with a voice to ask for help and ask questions about the situation that may be beneficial to find help in the time of need (Houston et al., 2015). An example is the request, which may not be to the level of calling 911, but a simple need of removing a tree blocking the driveway or asking if someone is nearby to help. Supplementary options should be considered with the same evolution as analog to digital communications signals used in a large-scale emergency for the wireless communication industry (Stephens, 2018). Understanding that the changes would be costly, what ought to be considered is whether the cost is worth the value to help reduce bureaucracy (Imran et al., 2015). AIDR may help with the costs of processing data effectively and categorizing it to flow data to the correct agencies (Imran et al., 2014). The benefit of the change to help the local government recover, return to a new normal, and rebuild more quickly (Masys, 2015).

The relationship to consider in reducing DIRS is planning for future disasters by reducing them with improvements, similar to Taiwan, by breaking down disasters into three aspects: emergency management center, disaster response, and disaster prevention. The more planning, the less reaction if a disaster affects an area, if it does at all. Reducing wildfires will reduce the effects on emergency communication. WEA is part of disaster response to help send communication quickly and clearly to reduce the time, which is an improvement that may be added to DIRS if a response is sent out and if the communication successfully reaches citizens (Stephens, 2019).

Discussion

With the growing number of emergency disasters being reported and affected countless citizens, the necessity for reliable disaster information systems has become an obligation to have work at a moment's notice. The aftermath of disasters should be considered, but planning to reduce the number of disasters in the first place should be given greater emphasis than cleaning up the aftermath. In the future, there should be fewer reports, because the fiber and electrical lines have been moved underground, where it is possible that towers and equipment on towers will be reinforced for stronger winds. Action to reduce flooding includes cleaning drain systems regularly in flood-prone areas and utilizing technology to find areas to minimize the impact of future disasters, concluding monitoring water levels in the area, and improving roads to withstand flooding impact during a weather event which could help with future disasters and reporting needs.

Practical Significance

Since Hurricane Katrina, the process of communication updates during a disaster and the viability of data from reporting shows progress in bringing attention to communication during a disaster. The concern of governmental bureaucracy is still an issue after 19 years of DIRS reporting (Federal Communications Commission, 2023). The first iPhone was not released until 2007, but the iPhone 16 was released in 2024 (Britannica, The Editors of Encyclopedia, 2024). Technology has changed from a pay phone on the corner to a simple flip phone to a small computer that makes calls. With these changes in society, smartphones, and ever-changing applications, the possibility of gathering real-time communication service data could become a reality. The time has come to move into the future and report on communication services being used now, as well as to expand for future technologies that will be here in a few short years. Considering the diverse systems being utilized to facilitate communication and help individuals in need during a disaster, it is necessary to provide services at a much faster rate.

P-20 Implications

The impacts of education in impacted areas of a disaster also need to be considered for future effects on students who have to move due to the impact on their homes to another school system post- disaster. The delays that students may have on each level, including higher education, with disruption of time to students, changing schools, loss of friends, and similarity of staff at the school that understand their needs (Wang, 2024). The impacts could be life-changing to students, including slowing down their educational growth and ability to reach their educational milestones in a timely manner. Education achievement could also cause mental stress, that could bring on additional issues for students maybe not noticed until years after changing schools. Providing assistance for displaced students and resources to help them stay on track with education will benefit the students, families, and local communities post-disaster (U.S. Department of Education, 2024).

Future education in emergency planning would provide a path to reduce emergency work by introducing research and implementing methods to reduce wildfires by clearing debris. Additional research is to consider the effects and then develop policies and initiatives for higher education that has been impacted by a declared emergency (Wang, 2024). Additional research on innovation to reduce flooding after a hurricane in an impacted area to reduce additional damage after a hurricane has made landfall. Also, it is essential to consider other countries' work and how they are already reducing flooding or wildfires. Along with engineering homes and businesses to withstand wind speeds in areas prone to hurricane-force winds, including inland from the coastal areas. The federal government's support with leadership and research to reduce emergencies, as well as help those who live in prone areas to reduce destruction, will help with future emergencies.

Limitations of the Study

Study limitations include the ever-changing amount of data being continuously added to DIRS, which has grown even since the start of this study. An additional limitation is the communication reports on Hurricane Maria on December 15, 2017, January 10, 2018, and Tropical Storm Henri on August 23, 2021 (Federal Communications Commission, 2024c). Each type of communication being reported is not standard to other communications on the report. An example is wireline and cable systems reports based on customers affected. In contrast, television and radio are based on the station being out of service, but not the affected population. Another limitation to consider is the affected population, which depends on the location of the reported disaster. A dense population may have a higher amount of wireless cell sites in the area than a low-populated area. The type of disaster is also a limitation due to the quantity of communications reports. An example is a wildfire, which may have one or two communication reports, while an F5 hurricane could have months of communication produced.

Recommendations for Future Research

Future research could consider the population at the time of the disaster along with the communication report to see how the population correlates with the data in DIRS. Understanding the affected population would help with future considerations if additional help is needed or the scale of the disaster affecting the population. An example is that the population in rural Kentucky is different than in Dallas, Texas, and the number of counties and communication systems are impacted. A standard format of data on communications reports for all broadcasting communications being reported on. An example is in the radio station section, which reports each station being affected, while wireless communication is listed by each county being affected. Contemplate that future reports consider malicious cyber-enabled activities as part of communication reports to be sent out. An example is the computer outage that affected the United States in July of 2024, which affected multiple communication systems, federal agencies, and airlines (Yan et al., 2024). Bringing in a different type of emergency affecting citizens in their day-to-day lives should also be considered.

References

Abrashoff, C. D. (2012). *It's your ship: Management techniques from the best damn ship in the Navy* (10th anniversary ed.). Grand Central Publishing.

Ali, A. L., van de Ven, J., Saphangthong, T., Freksa, C., Barkowsky, T., Thongmanivong, S., Chanthavong, H., & Haddawy, P. (2017, May 22-24). *Experience with the Mobile4D disaster reporting and alerting system in Lao PDR* [Conference paper]. 14th IFIP WG 9.4 International Conference on Social Implications of Computers in Developing Countries, Yogyakarta, Indonesia. https://doi.org/10.1007/978-3-319-59111-7_43

Annelli, J., (2006). *The national incident management system: a multi-agency approach to emergency response in the United States of America*. http://dx.doi.org/10.20506/rst.25.1.1656

Bedient, P. B. (2012). *Lessons from Hurricane Ike* (1st ed.). Texas A&M University Press.

Boin, A., Brown, C., & Richardson, J. A. (2019). *Managing hurricane katrina Lessons from a megacrisis.* LSU Press.

Brame, C., (2024). Just-in-time teaching (JiTT). *Vanderbilt University Center for Teaching*. https://cft.vanderbilt.edu/guides-sub-pages/just-in-time-teaching-jitt/

Britannica, T. Editors of Encyclopedia (2024). *iPhone*. *Encyclopedia Britannica*. https://www.britannica.com/technology/iPhone

Browning, L., Saaetre, A., Stephens, K., & Sornes, J. (2010). *Information & communication technologies in action: Linking theories and narratives of practice.* Routledge.

Buckles, E., Jr. (Director). (2022). *Katrina babies* [Film]. House of the Young Entertainment. https://www.hbo.com/movies/katrina-babies

CBS News (2012). Katrina, rita victims get $42.6m in toxi FEMA trailer suit. https://www.cbsnews.com/news/katrina-rita-victims-get-426m-in-toxic-fema-trailer-suit/

Chen, S.-T., & Hsu, C.-L. (2019). The research of debris flow disaster prevention and response system in Taiwan. *IOP Conference Series: Earth and Environmental Science*, *371*(3), Article 032063. https://doi.org/10.1088/1755-1315/371/3/032063

Collmann, J., & Matei, S. (2016). *Ethical reasoning in big data: An exploratory analysis*. Springer. https://doi.org/10.1007/978-3-319-28422-4

Douglas, R., Kocatepe, A., Barrett, A. E., Ozguven, E. E., & Gumber, C. (2019). Evacuating people and their pets: Older Floridians' need for and proximity to pet-friendly shelters. *The Journals of Gerontology: Series B, 74*(6), 1032–1040. https://doi.org/10.1093/geronb/gbx119

Fazelie, H., Said, M. Amerudin, S., & Abd Rahman, M. (2015). A study of volunteered geographic information (VGI) assessment methods for flood hazard mapping: A review. *Jurnal Teknologi*, *75*(10). https://doi.org/10.11113/jt.v75.5281

Federal Communications Commission. (2019). *Public Safety and Homeland Security Bureau seeks comment on improving the wireless resiliency cooperative framework.* https://docs.fcc.gov/public/attachments/DA-19-242A1.txt

Federal Communications Commission. (2022). *Resilient networks.* https://docs.fcc.gov/public/attachments/FCC-22-50A1.pdf

Federal Communications Commission. (2023). *Disaster Information Reporting System (DIRS) User Guide* (2.1).

Federal Communications Commission. (2024). *Disaster Information Reporting System (DIRS).* https://www.fcc.gov/general/disaster-information-reporting-system-dirs-0

Federal Communications Commission. (2024b). About the FCC. https://www.fcc.gov/about/overview

Federal Communications Commission. (2024c). About the FCC.

https://www.fcc.gov/past-response-efforts

Federal Emergency Management Agency. (2024). About us. https://www.fema.gov/about

Federal Emergency Management Agency. (2024b). Disaster Declarations for States and Counties. https://www.fema.gov/data-visualization/disaster-declarations-states-and-counties

Federal Register. Proposed rules. Proposed rule. Tuesday, March 31, 2020.

Franks, S. (2010). The neglect of Africa and the power of aid. *International Communication Gazette*, *72*(1), 71–84. https://doi.org/10.1177/1748048509350339

Gibson, A., Kusmaul, N., & Engelhardt, E. (2020). Older persons' use of social media for Communication during hurricane Matthew. *Innovation in Aging*, *4*(Supplement_1), 693–693. https://doi.org/10.1093/geroni/igaa057.2427

Goodwin, M. (2024). What is an API (application programming interface)? (https://www.ibm.com/topics/api)

Haworth, B. T. (2018). Implications of volunteered geographic information for disaster management and GIScience: A more complex world of volunteered geography. *Annals of the American Association of Geographers*, *108*(1), 226–240. https://doi.org/10.1080/24694452.2017.1321979

Hickman, H., Lakin, M. (2018). Gatlinburg tests new emergency sirens. https://www.knoxnews.com/story/news/local/2018/02/14/gatlinburg-test-new-emergency-siren-system-today/336293002/

Horowitz, A. (2020). *Katrina: A history, 1915-2015*. Harvard University Press.

Houston, J. B., Hawthorne, J., Perreault, M., Park, E., Goldstein Hode, M., Halliwell, M., McGowen, S., Davis, R., Vaid, S., McElderry, J., & Griffith, S. (2015). Social media and disasters: A functional framework for social media use in disaster planning, response, and research. *Disasters, 39*(1), 1–22. https://doi.org/10.1111/disa.12092

Imran, M., Castillo, C., Diaz, F., & Vieweg, S. (2015). Processing social media messages in mass emergency: A survey. *ACM Computing Surveys*, *47*(4), 1-38. https://doi.org/10.1145/2771588

Imran, M., Castillo, C., Lucas, J., Meier, P., & Vieweg, S. (2014). *AIDR: Artificial intelligence for disaster response* [Conference paper]. 23rd International Conference on World Wide Web, Seoul, Korea. https://doi.org/10.1145/2567948.2577034

Kuligowski, E. D. (2020). Field research to application: A study of human response to the 2011, Joplin tornado and its impact on alerts and warnings in the USA. *Natural Hazards (Dordrecht)*, *102*(3), 1057–1076. https://doi.org/10.1007/s11069-020-03945-6

Lowrie, C., Kruczkiewicz, A., McClain, S. N., Nielsen, M., & Mason, S. (2022). Evaluating the usefulness of VGI from waze for the reporting of flash floods. *Scientific Reports*, *12*(1), Article 5268. https://doi.org/10.1038/s41598-022-08751-7

Masys, A. J. (2015). *Disaster management: Enabling resilience.* Springer International Publishing. https://doi.org/10.1007/978-3-319-08819-8

Minick, J. (2023). Without warning: The tornado of Udall, Kansas. *University of Nebraska Press.*

Mittelstaedt, S. (2023). Unraveling the Maui tragedy. *The New American*, *39*(19), 18-21.

National Oceanic and Atmospheric Administration. (2024). https://www.noaa.gov/about-our-agency

National Oceanic and Atmospheric Administration. (2024b). https://www.nhc.noaa.gov/aboutsshws.php

Nieves, C. I. (2019). *Implications of language in emergency preparedness among Latino immigrants in New Jersey* [Doctoral dissertation, Capella University]. ProQuest Dissertations & Theses. https://www.proquest.com/dissertations-theses/implications-language-emergency-preparedness/docview/2318188197/se-2

Public Safety Canada. (2016). *Wildfire Fort McMurray AB*. Government of Canada. Retrieved June 25, 2024, from https://cdd.publicsafety.gc.ca/dtprnt-eng.aspx?cultureCode=en-Ca&eventTypes=%27WF%27&normalizedCostYear=1&dynamic=false&eventId=1135&prnt=both

Roy, K.C., Hasan, S., & Mosumder, P. (2020). A multilabel classification approach to identify hurricane-induced infrastructure disruptions using social media data. *Computer-Aided Civil and Infrastructure Engineering, 35*(12), 1387-1402. https://doi.org/10.1111/mice.12573

Rubin, C. (2012). *Emergency management the American experience 1900-2010*. CPC Press.

Saan, M., van Wesel, F., Leferink, S., Hox, J., Boeije, H., & van der Velden, P. (2022). Social network responses to victims of potentially traumatic events: A systematic review using qualitative evidence synthesis. *PloS One*, *17*(11), Article e0276476. https://doi.org/10.1371/journal.pone.0276476

Sadri, A., Hasan, S., Ukkusuri, S., & Cebrian, M. (2017). *Crisis communication patterns in social media during hurricane sandy*. https://doi.org/10.48550/arxiv.1710.01887

Select Bipartisan Committee. (2006a). *A failure of initiative: Supplementary report and document* (Report No. 109-396). U.S. Government Printing Office. https://biotech.law.lsu.edu/katrina/govdocs/109-377/sup/hr109-396.pdf

Select Bipartisan Committee. (2006b). *A failure of initiative: Final report of the Select Bipartisan Committee to investigate the preparation for and response to hurricane Katrina* (Report No. 109-377). U.S. Government Printing Office.

Stephens, K. (2018, September). *Breaking through barriers of connecting during disasters* [Video]. TED Conferences. https://www.ted.com/talks/keri_stephens_breaking_through_barriers_of_connecting_during_disasters

Stephens, K. (2019). *New media in times of crisis.* Routledge.

U.S. Department of Commerce National Oceanic and Atmospheric Administration. (2023). *Atlantic tropical cyclone reports.* https://www.nhc.noaa.gov/data/tcr/index.php?season=2005&basin=atl

U.S. Department of Education. (2024). U.S. Department of Education Highlights Resources to Support Communities Impacted by Hurricanes Helene and Milton. https://www.ed.gov/about/news/press-release/us-department-of-education-highlights-resources-support-communities

Vaillant, J. (2023). *Fire weather: A true story from a hotter world.* Penguin Random House.

Vogelsang, I. (2010). The relationship between mobile and fixed-line communications: A survey. *Information Economics and Policy*, *22*(1), 4-17. https://doi.org/10.1016/j.infoecopol.2009.12.002.

Wang J. (2024). Impact of natural disasters on student enrollment in higher education programs: A systematic review. *Heliyon, 10*(6), e27705. https://doi.org/10.1016/j.heliyon.2024.e27705

Wile, R. (2024). Elon Musk's starlink brings internet and politics to storm-ravaged areas. *NBC News*. https://www.nbcnews.com/business/business-news/elon-musk-starlink-brings-internet-politics-hurricane-helene-recovery-rcna173463

Yan, H., Afshar, P., Lear, J., & Yeung, J. (2024) 3*,000 flights are canceled as a global computer outage wreaks havoc on businesses, 911 systems, and government agencies*. CNN. https://www.cnn.com/2024/07/19/business/delta-american-airlines-flights-outage-intl-hnk/index.html

Zhao, M., Rosoff, H., & John, R. S. (2019). Media disaster reporting effects on public risk perception and response to escalating tornado warnings: A natural experiment. *Risk Analysis*, *39*(3), 535–552. https://doi.org/10.1111/risa.13205

Appendix A

Federal Communications Commission

Communications Status Report for Areas Impacted by Hurricane Zeta
October 31, 2020

The following is a report on the status of communications services in geographic areas impacted by Hurricane Zeta as of October 31, 2020 at 12:00 p.m. EDT. This report incorporates network outage data submitted by communications providers to the Federal Communications Commission's (FCC) Disaster Information Reporting System (DIRS). Note that the operational status of communications services during a disaster may evolve rapidly, and this report represents a snapshot in time.

The following counties are in the current geographic area that is part of DIRS (the "disaster area").

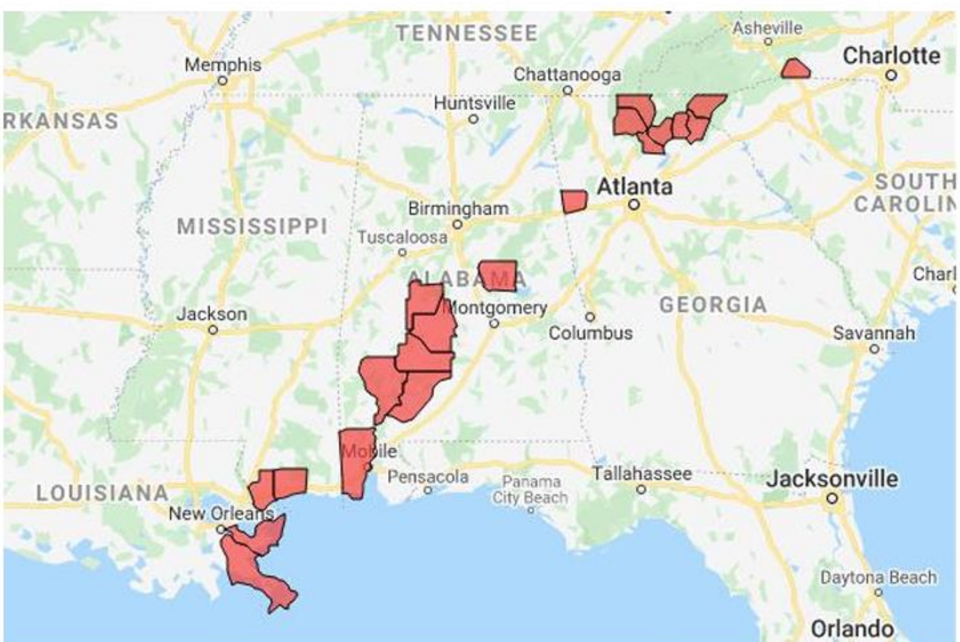
Alabama: Clarke, Coosa, Dallas, Mobile, Monroe, Perry, Wilcox

Georgia: Dawson, Fannin, Gilmer, Habersham, Haralson, Lumpkin, Rabun, White

Louisiana: Plaquemines, St. Bernard

Mississippi: Hancock, Harrison

North Carolina: Polk



Federal Communications Commission

911 Services

The Public Safety and Homeland Security Bureau (PSHSB) learns the status of each Public Safety Answering Point (PSAP) through the filings of 911 Service Providers in DIRS, reporting to the FCC's Public Safety Support Center, coordination with state 911 Administrators and, if necessary, direct contact with individual PSAPs.

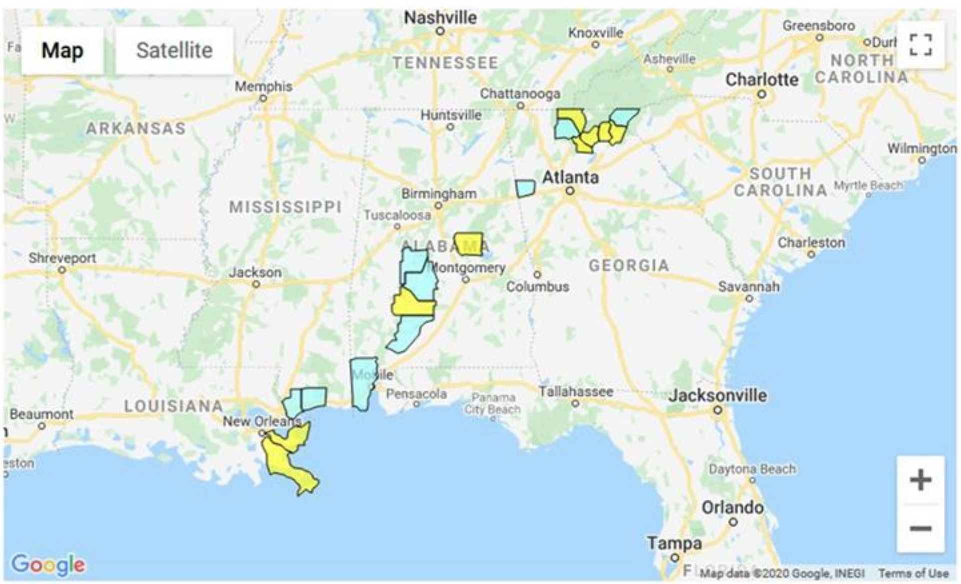
No PSAPs were reported being affected.

Wireless Services

The following section describes the status of wireless communications services and restoration in the disaster area, including the percentage of cell sites out of service for each county.

Percent Cell Sites Out-of-Service By County

10/31/2020 11:39:01 AM



1 - 15 16 - 30 31 - 45 46 - 60 61 - 100

The following table provides cell sites out of service by county. There are 8.6% of the cell sites out of service in the affected area. The information shown was provided by the signatories to the Wireless Network Resiliency Framework Cooperative Agreement.

Alabama

State	Affected Counties	Cell Sites Served	Cell Sites Out	Percent Out	Cell Sites Out Due to Damage	Cell Sites Out Due to Transport[1]	Cell Sites Out Due to Power
AL	CLARKE	32	0	0.0%	0	1	1
AL	COOSA	50	8	16.0%	3	0	5
AL	DALLAS	54	5	9.3%	4	0	1
AL	MOBILE	514	10	1.9%	6	1	3
AL	MONROE	31	1	3.2%	0	1	0
AL	PERRY	19	1	5.3%	0	1	0
AL	WILCOX	30	8	26.7%	0	1	8
TOTAL		**730**	**33**	**4.5%**	**13**	**5**	**18**

Georgia

State	Affected Counties	Cell Sites Served	Cell Sites Out	Percent Out	Cell Sites Out Due to Damage	Cell Sites Out Due to Transport	Cell Sites Out Due to Power
GA	DAWSON	38	6	15.8%	3	0	3
GA	FANNIN	30	7	23.3%	0	2	5
GA	GILMER	44	2	4.5%	0	1	1
GA	HABERSHAM	45	9	20.0%	5	0	4
GA	HARALSON	40	1	2.5%	1	0	0
GA	LUMPKIN	45	12	26.7%	10	1	2
GA	RABUN	22	2	9.1%	0	0	2
GA	WHITE	34	9	26.5%	8	0	0
TOTAL		**298**	**48**	**16.1%**	**27**	**4**	**17**

Louisiana

State	Affected Counties	Cell Sites Served	Cell Sites Out	Percent Out	Cell Sites Out Due to Damage	Cell Sites Out Due to Transport	Cell Sites Out Due to Power
LA	PLAQUEMINES	58	11	19.0%	3	1	8
LA	ST. BERNARD	39	8	20.5%	3	0	5

[1] These are cell sites that are out due to issues with the (typically wireline) networks that route communications traffic to and from the cell sites.

TOTAL		97	19	19.6%	6	1	13

Mississippi

State	Affected Counties	Cell Sites Served	Cell Sites Out	Percent Out	Cell Sites Out Due to Damage	Cell Sites Out Due to Transport	Cell Sites Out Due to Power
MS	HANCOCK	63	4	6.3%	2	0	2
MS	HARRISON	218	18	8.3%	12	0	6
TOTAL		**281**	**22**	**7.8%**	**14**	**0**	**8**

North Carolina

State	Affected Counties	Cell Sites Served	Cell Sites Out	Percent Out	Cell Sites Out Due to Damage	Cell Sites Out Due to Transport	Cell Sites Out Due to Power
NC	POLK	18	0	0.0%	0	0	0
TOTAL		**18**	**0**	**0.0%**	**0**	**0**	**0**

The number of cell site outages in a specific area does not necessarily correspond to the availability of wireless service to consumers in that area. *See* Improving the Resiliency of Mobile Wireless Communications Networks, Order, 31 FCC Rcd 13745, para. 10 (2016) (recognizing the difficulties in accurately depicting the ongoing status of a wireless provider's service during emergencies). Wireless networks are often designed with numerous, overlapping cell sites that provide maximum capacity and continuity of service even when an individual site is inoperable. In addition, wireless providers frequently use temporary facilities such as cells-on-wheels (also known as COWs), increased power at operational sites, roaming agreements, or take other actions to maintain service to affected consumers during emergencies or other events that result in cell site outages.

Cable Systems and Wireline (Combined)

Cable and wireline companies reported 149,863 subscribers out of service in the affected areas; this may include the loss of telephone, television, and/or Internet services.

Broadcast:

- No TV stations reported being out of service.
- 1 FM radio stations reported programming sent to another station (KMEZ).
- 3 AM radio stations reported being out of service (WSGN, WSHO, WYLD).

Appendix B

Table 1

Results of DIRS with and without Hurricane Maria

	PSAP		Television		Radio		Wireless Communication		Cable Systems and Wireline Service	
	With	Without	With	Without	With	Without	With	Without	With	Without
Mean	0.13	0.11	0.57	0.67	1.02	1.07	9.27	5.94	166,784.14	219,400.56
Median	0	0	1	1	1	1	2	0	16,700	53,646.5
Mode	0	0	1	1	1	1	0	0	0	0
Range	1	1	6	6	21	21	1,019	1,019	8,258,789	8,258,789
Minimum	0	0	0	0	0	0	0	0	0	0
Maximum	1	1	6	6	21	21	1,019	1,019	8,258,789	8,258,789
Sum	49	34	299	267	4,745	1,711	200,044	78,178	73,718,588	73,718,588
Count	392	286	523	399	4,640	1,595	21,578	13,153	442	336

Appendix C

Table 2

Results of DIRS with the Number of Television Stations Out of Service by Hurricane

Year	Disaster's Name	Count
2016	Hurricane Matthew	5
2017	Hurricane Harvey	14
2017	Hurricane Maria	32
2017	Hurricane Irma	66
2018	Hurricane Lane	3
2018	Hurricane Florence	30
2018	Hurricane Michael	30
2019	Tropical Storm Barry	1
2019	Hurricane Dorian	3
2020	Hurricane Delta	7
2020	Tropical Storm Macro and Hurricane Laura	18
2021	Hurricane Ida	31
2022	Hurricane Fiona	9
2022	Hurricane Ian	17
2023	Typhoon Mawar	31
2024	Hurricane Debby	2

Appendix D

Table 3

Results of DIRS with the Number of Radio Stations Out of Service by Hurricane

Year	Disaster's Name	Count
2016	Hurricane Matthew	118
2017	Hurricane Harvey	81
2017	Hurricane Irma	252
2017	Hurricane Maria	3,034
2017	Hurricane Nate	0
2018	Hurricane Florence	234
2018	Hurricane Lane	12
2018	Hurricane Michael	137
2019	CA Power Shutoff	41
2019	Hurricane Dorian	11
2019	Tropical Storm Barry	1
2020	Hurricane Delta	45
2020	Hurricane Sally	14
2020	Hurricane Zeta	19
2020	Midwest Derecho	60
2020	Puerto Rico Earthquake	0
2020	Tropical Storm Isaias	0
2020	Tropical Storm Laura	0
2020	Tropical Storm Macro and Hurricane Laura	193
2021	Hurricane Ida	117
2021	Hurricane Ida and Nicholas	9
2021	Kentucky Tornadoes	0
2022	Hurricane Fiona	70
2022	Hurricane Ian	114
2022	Hurricane Nicole	4
2022	New Mexico Wildfires	0
2022	Puerto Rico Power Outage	0
2022	Winter Storm	1
2023	Hawaii Wildfires	34
2023	Hurricane Idalia	12
2023	Hurricane Lee	0
2023	Tropical Storm Hilary	2
2023	Typhoon Mawar	71
2024	Hurricane Beryl	26
2024	Hurricane Debby	6

2024	New Mexico Wildfires 2024	21
2024	Tropical Storm Ernesto	6

Appendix E

Table 4

Results of DIRS with the Number of Cable Systems and Wireline Customers Out of Service by Hurricane

Year	Disaster's Name	Count
2016	Hurricane Matthew	1,344,951
2017	Hurricane Harvey	2,227,458
2017	Hurricane Irma	36,240,881
2017	Hurricane Maria	0
2017	Hurricane Nate	1,589
2018	Hurricane Florence	1,943,954
2018	Hurricane Lane	22,980
2018	Hurricane Michael	2,430,318
2019	CA Power Shutoff	1,430,431
2019	Hurricane Dorian	388,874
2019	Tropical Storm Barry	97,834
2020	Hurricane Delta	689,121
2020	Hurricane Sally	779,612
2020	Hurricane Zeta	1,247,999
2020	Midwest Derecho	230,187
2020	Puerto Rico Earthquake	630,566
2020	Tropical Storm Isaias	487,102
2020	Tropical Storm Laura	80,936
2020	Tropical Storm Macro and Hurricane Laura	2,154,802
2021	Hurricane Ida	4,332,967
2021	Hurricane Ida and Nicholas	550,804
2021	Kentucky Tornadoes	86,352
2022	Hurricane Fiona	6,814,980
2022	Hurricane Ian	4,259,492
2022	Hurricane Nicole	231,275
2022	New Mexico Wildfires	8,331
2022	Puerto Rico Power Outage	342,061
2022	Winter Storm	13,700
2023	Hawaii Wildfires	218,906
2023	Hurricane Idalia	129,609
2023	Hurricane Lee	2,413
2023	Tropical Storm Hilary	76,391
2023	Typhoon Mawar	60,249
2024	Hurricane Beryl	3,046,723

2024	Hurricane Debby	134,907
2024	New Mexico Wildfires 2024	15,245
2024	Tropical Storm Ernesto	964,588

Appendix F

Table 5

Results of DIRS with the Number of Wireless Communication Sites Out of Service by Hurricane

Year	Disaster's Name	Count
2016	Hurricane Matthew	341
2017	Hurricane Harvey	485
2017	Hurricane Irma	1,194
2017	Hurricane Maria	8,425
2017	Hurricane Nate	8
2018	Hurricane Florence	849
2018	Hurricane Lane	15
2018	Hurricane Michael	1,029
2019	CA Power Shutoff	230
2019	Hurricane Dorian	444
2019	Tropical Storm Barry	146
2020	Hurricane Delta	216
2020	Hurricane Sally	136
2020	Hurricane Zeta	387
2020	Midwest Derecho	168
2020	Puerto Rico Earthquake	468
2020	Tropical Storm Isaias	32
2020	Tropical Storm Laura	159
2020	Tropical Storm Macro and Hurricane Laura	2,718
2021	Hurricane Ida	841
2021	Hurricane Ida and Nicholas	140
2021	Kentucky Tornadoes	102
2022	Hurricane Fiona	1,020
2022	Hurricane Ian	517
2022	Hurricane Nicole	68
2022	New Mexico Wildfires	30
2022	Puerto Rico Power Outage	156
2022	Winter Storm	366
2023	Hawaii Wildfires	14
2023	Hurricane Idalia	140
2023	Hurricane Lee	10
2023	Tropical Storm Hilary	14
2023	Typhoon Mawar	59
2024	Hurricane Beryl	33
2024	Hurricane Debby	339

2024	New Mexico Wildfires 2024	10
2024	Tropical Storm Ernesto	276

Appendix G

MURRAY STATE UNIVERSITY

Institutional Review Board

328 Wells Hall
Murray, KY 42071-3318
270-809-2916• msu.irb@murraystate.edu

TO: Dr. Landon Clark, and Katie Nelson

FROM: Reigh Kemp, IRB Coordinator

DATE: September 18, 2024

RE: Human Subjects Protocol I.D. – IRB # 25-020

Project Title: *Silence is Not Golden: Exploring the Trade-Offs Between Transparency and Burden in DIRS*
Student Principal Investigator(s): Katie Nelson
- **Faculty Sponsor:** Dr. Landon Clark

Determination: Not Generalizable - Activity is not research as defined in 45 CFR 46.102(l)

The Murray State University IRB has reviewed the information you supplied for the project named above. Based on that information, it has been determined that this project does not involve activities and/or subjects that would require IRB review and oversight. The IRB will keep your determination form on file for a period of 3 years.

Please note that there may be other Federal, State, or local laws and/or regulations that may apply to your project and any changes to the subjects, intent, or methodology of your project could change this determination. You are responsible for informing the IRB of any such changes so that an updated determination can be made. If you have any questions or require guidance, please contact the IRB Coordinator for assistance.

Thank you for providing information concerning your project.