2021

Variations in ED Visits During Hurricane Irma in Florida and Potential Cost Savings Using Telehealth

Parnaz Rafatjou
Medical University of South Carolina

VARIATIONS IN ED VISITS DURING HURRICANE IRMA IN FLORIDA AND POTENTIAL COST SAVINGS USING TELEHEALTH

BY

Parnaz Rafatjou

A doctoral project submitted to the faculty of the Medical University of South Carolina
in partial fulfillment of the requirements for the degree
Doctor of Health Administration
in the College of Health Professions

Acknowledgments

I want to express my heartfelt gratitude to my beautiful family for their unconditional love and support throughout the years. This work is dedicated to my three relentless cheerleaders. My mom, Badri Lajevardi, is one of the strongest women I know who has always led by example that dreams can be achieved no matter how challenging the path may seem. My dad, Ahmad Rafatjou, has always provided us with the best opportunities and continues to believe in our potential. Words cannot express how thankful I am to my brother, Parham Rafatjou, for always putting my interests ahead of his and being someone, I can lean on. I continue to learn from his bravery to take bold steps and make life-changing decisions.

Thanks to the love and support of my only living grandmother, who beams with pride when she sees how far her family has come. I am grateful to my extended family and close friends for their encouragement from near and far. I cannot wait to celebrate the successes of the young ones in our family. This unforgettable journey is coming to an end but is only the beginning of the next chapter. My success is the byproduct of the support of brilliant committee members. Dr. Annie Simpson (chair) led me patiently and diligently through this process and encouraged me to make it my own. Dr. Kit Simpson (committee member) is the heart and soul of the DHA program; this doctoral project became a reality only because she knew how to align my interests to a clear literature gap. Dr. Dean Doering (committee member), an alumnus of the DHA program, brought remarkable expertise to this project with his background, and I am fortunate to have him as a mentor and friend.

I cannot express enough appreciation to the rest of the faculty members, professors, and other support staff, including Dr. Jillian Harvey, Rebecca Barry, Leslie Anderson, and our Research & Education Informationist, Christine Andresen. I was fortunate to be part of an incredible cohort that bonded immediately and will continue to remain friends. My thanks to my many mentors, especially Dr. Jeremy Howell, for planting the seed of encouragement and steering me toward the DHA program. I am grateful, proud, and humbled to join the ranks of my fellow MUSC Doctor of Health Administration Alums.

Abstract of Dissertation Presented to the
Medical University of South Carolina
In Partial Fulfillment of the Requirements for the
Degree of Doctor of Health Administration

VARIATIONS IN ED VISITS DURING HURRICANE IRMA IN FLORIDA AND POTENTIAL COST SAVINGS USING TELEHEALTH

by

Parnaz Rafatjou

Chairperson:	Annie N. Simpson, PhD
Committee:	Kit N. Simpson, DrPH
	Dean E. Doering, DHA

Abstract

Background: Periods of natural disasters like hurricanes can lead to traumas, worsening of existing medical conditions, travel restrictions, or healthcare systems' inability to provide critical and timely care. A promising approach is telehealth use to provide care to remote patients in shelters or their homes. However, there is a need to better understand evacuees' behavior and ED use during such events.

Methods: We conducted a retrospective study using 2017 archival billing data in Florida during Hurricane Irma. The NYU ED algorithm was used to classify visits into emergent and non-emergent categories. Comparison groups included counties under mandatory evacuations and those with extended power outages. Comparison timelines were defined as pre-, post-, and hurricane quarters.

Results: Hurricane evacuations caused more individuals to seek emergent and non-emergent care outside of their home counties during the hurricane quarter. Extended power outages caused an increase in in-county emergent and non-emergent visits after the hurricane. Telehealth could have potentially led to over $296 M in cost savings during the hurricane quarter.

Discussion: Telehealth investments can be extended to meet the needs of a disaster-affected population. The availability of a robust telehealth infrastructure, appropriate planning and resource allocation, and supporting policies and regulation can make the continuity of care possible.

Table of Contents

List of Figures

List of Tables

CHAPTER I: INTRODUCTION AND BACKGROUND

1.1 Background

Advances in technology have enabled scientists and researchers to collect data on global climate change through rock formations, tide gauges, and, more recently, satellite images. The National Aeronautics and Space Administration (NASA) (2020) and other researchers attribute the current global climate change trends to the expansion of humans' greenhouse effects. Certain gases are released into the atmosphere and block the heat from escaping the surface of the earth. These gases include water vapor, carbon dioxide, methane, nitrous oxide, and chlorofluorocarbons. Many human activities following the industrial revolution have contributed to releasing these gasses, including the burning of fossil fuels, modern agricultural practices, production and use of synthetic materials, and much more (NASA, 2020).

According to the National Oceanic and Atmospheric Administration (NOAA) (2020), there is a linkage between hurricanes' intensity in the North Atlantic and the increase in regional temperatures and convergence and uplifting in ocean waves. Further, NOAA (2020) found that hurricane seasons continue to get longer with a tendency to start earlier or end later. The increased evaporation and more massive amounts of atmospheric water vapor and other gasses increased the rainfall during Hurricanes Katrina, Irma, and Maria between 2005 and 2019 (NOAA, 2020). The latest Atlantic Hurricane Season report issued by NOAA (2020), highlights a record-breaking season with 30 named storms, 12 of which made landfall in the continental United States (NOAA, 2020).

Emanuel (2017) notes between 1970 and 2010, the number of global populations exposed to tropical cyclones and hurricanes increased threefold. Between 1970 and 2015, the damages from storms rose approximately 6% every year (Emmanuel, 2017). Smith and Matthews (2020) posit that in 2019 alone, the United States (U.S.) experienced 14 multi-million-dollar disasters that included inland floods, severe storms, tropical cyclones, and a wildfire. The frequency of billion-dollar disasters in the U.S. over the past two decades is depicted in Figure 1 (Smith and Matthews, 2020).

Between 2017 and 2019, the number of natural disasters added to 44, a dozen of them reached billion-dollar marks (Smith & Mathews, 2020). Four of the five most destructive disasters in the U.S. included Hurricanes Harvey, Irma, Maria, and Sandy throughout the 2010s. In 2012, Hurricane Sandy made landfall in New York and New Jersey as a strong tropical storm in highly developed areas. More recently, Harvey, a category four hurricane, flooded over one-third of Houston, Texas, in 2017 after dropping more than 27 trillion gallons of rain (Inserra et al., 2018). Hurricane Irma followed Harvey in the same year with such powerful force that it was recorded on earthquake seismometers and generated seven trillion watts of energy. The wind gusts were clocked at 199 miles per hour and extended to 185 miles from the center over 37 consecutive hours. The above-average ocean temperatures sustained the storm for a more extended period (Amadeo, 2019).

Hurricane Irma hit the northern parts of Haiti, the Dominican Republic, Cuba, the U.S. Virgin Islands, Puerto Rico, Florida, Georgia, and North Carolina from August 30 through September 13, 2017. Overall, 13 emergency declarations were issued for Hurricane Irma. On September 15, President Trump declared a state of emergency in Florida that included all counties (FEMA, 2018). The Florida Governor, Rick Scott, issued his first state of emergency for the Keys' residents on September 4, noting that all Floridians should prepare for possible evacuations (Amadeo, 2019).

NASA (2018) predicts that the effects of global climate change are more severe than initially anticipated. The resulting trends will continue throughout this century and well beyond. Recent hurricanes in Florida have increased in intensity and contributed to staggering human life and monetary losses (Craig, 2019; Smith & Matthews, 2020). The frequency of billion-dollar events in Florida is highlighted in Figure 2 (NOAA, 2020). Recent Massachusetts Institute of Technology (M.I.T.) models project more hurricanes developing from climate change, El Nino, and other regional variations between now and 2035. The models also suggest that 11% of these hurricanes will be categories three, four, five, or even soon to be designated category six (Emanuel, 2017; Amadeo, 2019).

1.2 Problem Statement

High-intensity hurricanes' severity and frequency are of notable importance to the public, policymakers, healthcare delivery systems, and emergency teams. The accumulated costs, death tolls, and long-term health outcomes of natural disasters may be reduced substantially through better preparedness, early investments, implementation of more effective policies, and improved resource availability (Smith & Mathews, 2020). Severe storms and hurricanes can cause accidents, trauma, drowning, and electrocution. These disasters can also result in carbon monoxide poisoning, vehicle accidents, and disruption of emergency services (Issa et al., 2018).

There are numerous suicides, homicides, anxiety or post-traumatic stress disorder (PTSD) events following hurricanes that are not linked to the officially released numbers due to challenges with association or correlation of these conditions with a particular event. Healthcare providers, emergency service respondents, and other community resources have been investing in equipment, capacity, and training to prepare for emergencies (Issa et al., 2018; French et al., 2020).

During power outages, severe rain, or flooding, it may at times be impossible to reach those patients that are in critical conditions such as those in nursing facilities, hospice, or even the ones with chronic conditions who live at home. Similarly, it would be difficult to ship or receive medical supplies to relevant parties during extreme conditions (Inserra et al., 2018). During severe hurricanes, emergency medical services (EMS) are only dispatched if they can reach the patients in the affected area. Once the EMS arrives at the location, it may become difficult to transfer patients to a facility in a timely manner. Hence, telehealth has become of growing importance for many local agencies and health systems to provide care to remote patients and access medical expertise (French et al., 2010).

1.3 Significance

According to the Centers for Medicare and Medicaid Services (CMS) (2019), U.S. healthcare spending increased by 4%, reaching over $3.5 trillion by the end of 2017. This $11,000 per capita healthcare spending translated to approximately 18% of the U.S. gross domestic product (GDP) in 2017. The data also showed increases in hospital care spending by 4.6%, physician and clinical services by

4.2%, retail prescription drugs by 0.5%, home health by 4.3% and other health, and personal care services by 5.6% in 2017 (CMS, 2019).

A recent report released by Johns Hopkins University (2019) shows that Florida's total healthcare spending is above 18% of the gross state product. Spending per capita in Florida appears to be the highest among neighboring states. These high expenditures have contributed to Florida's hospital prices to be among the highest in the nation (Johns Hopkins University, 2019). The spending increases are not sustainable even with the billions in additional emergency funding for rescue and recovery efforts after a natural disaster (CMS, 2019).

Further, while some healthcare facilities may have to close, others experience an unusually high volume of evacuees' visits. The surge in the number of emergency department (ED) visits puts a significant strain on healthcare workers, local emergency transport, and the local and state health systems and increases overall healthcare spending. Hence, it is essential to analyze the cost and variations in ED visits during a severe disaster and offer recommendations to help inform providers, policymakers, and patients of timely, evidence-based, patient-centric, cost-effective, and quality care.

1.4 Research Questions

This Doctoral Project was designed to provide a detailed assessment of ED use variations for medical events during an intense hurricane compared to regular times. A retrospective descriptive analysis of ED visits was conducted using archival billing data during the 2017 Hurricane Irma in Florida. The literature review discussed in the next section indicates little is known about evacuees' behavior during and after natural disasters.

This project explored three specific research questions:

1. What were the dynamics of ED care visits before and after Hurricane Irma?
   a) What proportion of and where did patients living in counties under mandatory evacuations seek ED care pre- and post-hurricane?

b) What proportion of and where did patients affected by extended power outage seek ED care pre- and post-hurricane?

2. What variations in volume and type of ED visits did we see in patients?

a) What variations in care-seeking volume did we see pre- versus during the quarter of hurricane landfall between in-county visits and out-of-county visits and between emergent and non-emergent visit types in counties affected by mandatory evacuation orders?

b) What variations in care-seeking volume did we see during the quarter of hurricane landfall versus post-hurricane between in-county visits and out-of-county visits and between emergent and non-emergent visit types in counties affected by extended power outages?

3. How many and what types of care may be served using telehealth leading to potential cost savings?

CHAPTER II: LITERATURE REVIEW

This study's literature review included distinct Medical Subject Headings (MeSH) terms to assess telehealth adoption during natural disasters (Table 1). The search from PubMed, Scopus, CINAHL, and ProQuest databases resulted in 820 items limited to peer-reviewed articles and original research published over the past five years (2015-2020). After removing duplicates and eliminating the studies that were not directly related to the analysis, 38 relevant and US-centric articles were selected.

The review indicated that more qualitative studies were conducted to illuminate the concept of using telehealth during natural disasters such as hurricanes. The qualitative studies included lessons learned, evaluations of telehealth modalities, systematic reviews, surveys, semi-structured interviews, and observational case studies. The original research included a mix of pilots, cohort studies, and assessment of customized telehealth modalities. The majority of pilot projects were designed to address the healthcare needs during natural disasters; however, they were not conducted during those events.

Most quantitative studies focused on applying telehealth during hurricanes and storms, while other studies discussed various natural disasters. Overall, the number of quantitative studies has only slightly increased since 2017 and includes data from multiple sources such as Veterans Affairs (VA), local Fire Department/EMS, Doctor on Demand, and condition-specific apps. Nearly a third of the quantitative studies were specific to VA beneficiaries' use of telehealth. VA articles' prevalence may be partially due to proactive investments in telehealth and data available through the VA.

While the VA data analysis has come the farthest for a large US-based health system, more investigation is needed to understand telehealth's use and potential benefits during natural disasters. One VA study analyzed the number and percentage of telehealth services 30 days before and after three hurricanes in 2017 at three different clinics (Der-Martirosian et al., 2020). Another VA study illustrated telehealth service usage 12 months before and after Hurricane Sandy in Manhattan (Der-Martirosian et al., 2019). A third study analyzed the percentage and number of business days for completing appointments 12 weeks before and after a hurricane (Radcliff et al., 2018).

In studies conducted from other sources, one EMS article assessed ED's utilization across seven hurricane shelters 12 days after Hurricane Florence in North Carolina (Grover et al., 2020). Two studies in Galveston and Charleston compared 911 calls and EMS transport volume during and after hurricanes Harvey and Florence (Crutchfield & Harkey, 2019; French et al., 2020). A fourth case-control study analysis from the EMS data in Houston conducted a cost-benefit analysis (CBA) of telehealth in 911 triage and hospital care (Langabeer II et al., 2016). Based on this literature search, the latter study has been the only CBA attempting to establish a linkage between the impact of pre-hospital triage using telehealth on ambulance transportation and hospitalizations.

An analysis of the Doctor on Demand data 30 days after Hurricanes Harvey and Irma in 2017 evaluated the volume of requests, patient characteristics, and chief complaints (Uscher-Pines et al., 2018). The only prospective, longitudinal, multidimensional analysis conducted across the U.S. was specific to asthma patients using a mobile app. The continued participation and the use of other data sources in the latter study set the stage for more robust analyses that would consider social determinants of health and public health implications (Chan et al., 2017).

2.1 Dynamics in Telehealth Use During Natural Disasters

The severity of flooding and high winds or the shifting paths of storms often limit access to patients. Many patients rely on the US Postal Service activities to receive their medications. Unavailability of ambulances, impassable roads, and traffic flow changes due to evacuations are only some examples of why patients may not get the care they need during and immediately after a hurricane. Overall, the resources are limited during a natural disaster, especially if medical providers also have to evacuate (French et al., 2020; Der-Martirosian et al., 2019). Some ways health systems have adopted telehealth interventions during natural disasters are listed below.

Prehospital assessments: Nearly 250 million 911 calls are received by approximately 20,000 EMS agencies in the US every year. These agencies are resource-constrained; however, they continue to respond to increasing transports and non-urgent complaints. The inquiries are even higher during natural disasters (Langabeer II et al., 2016; Winburn et al., 2018). In disaster-affected areas, the use of telehealth for prehospital care and triage has increased. Stroke, cardiovascular, and trauma triage make up over 80% of prehospital telehealth consultations using various modalities (Uscher-Pines et al., 2016; Winburn et al., 2018).

Prominence in adoption: In the pre COVID-19 era, the use of telehealth appears to be more prominent across the VA facilities due to their early and substantial investments in telehealth (Der-Martirosian et al., 2020). Many veterans live in remote areas, and technology provides better access to care for them. The adoption of telehealth has also been supported by some academic medical centers (AMCs) and several private companies across the nation. AMCs and local EMS partnerships during natural disasters have led to innovative ways to provide consultations for trauma or subacute phase of disaster response (French et al., 2020; Grover et al., 2020). Available literature suggests that most healthcare providers continue to spend more of their resources on frequent and immediate needs versus preparing for infrequent natural disasters or better access to care through telehealth for their communities (Andrews & Quintana, 2015).

Telehealth interventions: In the studies where telehealth was researched or deployed during natural disasters to provide care for patients, the chief complaints included injury, general pain, respiratory distress, chest pain, primary care triage, and mental health (Crutchfield & Harkey, 2019; Der-Martirosian et al., 2019; Radcliff et al., 2018). One study identified that acute respiratory illnesses and skin problems came up during many telehealth interactions immediately during or after the hurricane. However, during the first seven days post-event, inquiries for chronic conditions, consulting, refills, injuries, and back and joint problems increased (Uscher-Pines et al., 2018).

2.2 Benefits and Opportunities of Telehealth Use

Telehealth adoption is no longer designed only to serve the sick, poor, or those living in rural areas; it has become instrumental in expediting the medical response efforts during and after disasters (Der-Martirosian et al., 2020). While telehealth remained mainly underutilized in the pre-COVID-19 era, many established health systems across the US and those with presence in the states along the coastlines began investing in increased telehealth capabilities (Lurie & Carr, 2018).

EMS utilization: The higher patient volume in EDs resulting from increased EMS transfers and other hospital closures during hurricanes contribute to longer wait times and challenge routine triage procedures (French et al., 2020). Lack of appropriate staffing in EDs, ICUs, and limited availability of specialists, intensivists, and trauma surgeons add a toll to an already overburdened system (Crutchfield & Harkey, 2019; Andrews & Quintana, 2015; Rolston & Meltzer, 2015). Experts and medical providers' unequal distribution also creates challenges for shelter medical staff and patients who depend on e-consultations and triage through telehealth (French et al., 2020).

Telehealth use in the subacute phase of disaster response has proven to reduce the strains on EMS and unnecessary transports while providing care at the point of need and enhancing care quality (Grover et al., 2020; Pamplin et al., 2019). Delivery of routine follow-ups and care provisioning without increased hospital readmissions and early access to medication in preparation for a hurricane have proven to be particularly effective (Grover et al., 2020).

Improved triage: The use of telehealth provides an opportunity to manage the surge of visits from injuries, chronic conditions, and other clinic closures during a natural disaster (Lurie & Carr, 2018). Some health systems have used their tele-ICU capabilities for simulation scenarios and improved triage and early management of critical cases (Rolston & Meltzer, 2015). Similarly, telehealth has been used by healthcare professionals in shelters to triage patients with the help of e-consultations and to expedite the time for surveillance, detection, and monitoring of patients (Wood et al., 2019).

Reduced cost: Telehealth has the potential to contribute to cost savings during natural disasters through reduction of hospital transfers, utilization of a pool of designated staff for e-consultations for multiple sites, and reduction of scheduling and rescheduling patients during unpredictable times after natural disasters (Pamplin et al., 2019; Radcliff et al., 2018). Patients without insurance or those of limited socioeconomic means may experience potential complications by postponing a doctor’s visit during and after a natural disaster, hence unintentionally incurring more healthcare costs for the system. In some states, health systems equipped with telehealth capabilities have offered free services during and up to some time after hurricanes. Utilizing free services could eliminate higher future healthcare expenditures (Uscher-Pines et al., 2018).

Better preparedness: In some states, the expansion of telehealth with state and local agencies' help resulted in improved preparedness and a better understanding of the type and volume of requests received during natural disasters (French et al., 2020). The partnership between the health systems and local state agencies has allowed for a better system- and state-wide resource planning and staff training. The collaboration has also allowed for the arrangement of the needed equipment, operating room capacity increase, and trauma surgeons' availability during and after hurricanes (French et al., 2020; Crutchfield & Harkey, 2019).

Improved collaboration: Coordination among health systems and local agencies has reduced the overall deaths through collaborative initiatives that include predicting, planning, and preparing for natural disasters. Partnerships between emergency physicians at the telehealth hub, the local EMS, or shelter medical personnel have also created many benefits and opportunities. The live two-way encounters during and after hurricanes have expedited the time to evaluate, examine, and triage patients more effectively. The inclusion of local pharmacies has helped deliver the appropriate prescriptions to the patients while reducing potential medication errors or adverse effects. These engagements provide real-time mentorship that allows all sides to enhance their readiness (French et al., 2020; Grover et al., 2020; Pamplin et al., 2019).

Process improvement: The states with effective partnerships saw increased adoption of electronic health record (EHR) systems and additional investments in the broadband network (Andrews & Quintana, 2015). Telehealth has also presented an opportunity for many healthcare systems for continuous and regular documentation and the adoption and evolution of existing procedures between virtual and in-person visits. Health systems that choose to assign their physicians on telehealth consultations have opted to integrate their telehealth capabilities with in-house EHR systems (French et al., 2020; Doarn et al., 2018). Three proven benefits of this best practice have resulted in reduced paperwork, higher success in critical cases like stroke intervention, and the use of an embedded algorithm for easier access to evidence-based interventions for more accurate diagnosis and reduced errors (Elliott & Yopes, 2019; Yuen et al., 2016; Andrews & Quintana, 2015; Wood et al., 2019).

Remote patient monitoring: Disaster-related care can exacerbate existing chronic conditions during and after an event. Many patients often don't have their medications or devices with them when they arrive at the ED or in a shelter, leading to exacerbating chronic conditions during the long wait times (Radcliff et al., 2018). There is limited research on the continued need for care beyond an actual disaster. However, a study by Augusterfer et al. (2018) found that increase in conditions such as coronary artery disease, diabetes, drug abuse, high blood pressure, and risk for suicide substantially increased 3-5 years after the event occurred.

While there has been a significant uptake in telehealth for behavioral and mental health diagnoses and intervention, there is still a stigma attached to these conditions. The US adolescents and post-disaster populations remain under-diagnosed, especially those in remote areas. Chronic and mental interventions are among the most prominent conditions in the US; remote patient monitoring (RPM) and disease management using telehealth can offer timely access to care to patients while protecting their privacy (Bunnell et al., 2017; Price et al., 2015).

2.3 Barriers for Telehealth Use

As noted earlier, telehealth has brought many opportunities and benefits to disaster-stricken areas assuming that there is an available and fully functioning infrastructure in place (Doarn et al., 2018). However, there are still many barriers to entry for investments in and the use of telehealth.

Infrastructure needs: The most significant barriers during natural disasters noted in the literature review pointed to disruptions in telecom, network services, and power outages (Der-Martirosian et al., 2020; Der-Martirosian et al., 2019; Pamplin et al., 2019; Price et al., 2016; Rolston & Meltzer, 2015). Disruptions in electrical grids have affected many patients dependent on oxygen or dialysis devices over a series of natural disasters (Crutchfield & Harkey, 2019). Further, lack of good wireless or mobile connection, limited bandwidth, oversubscription of cellular towers, and technology issues have been the leading barriers in using telehealth across various settings during natural disasters (French et al., 2020; Grover et al., 2020; Uscher-Pines et al., 2018). Real-time visual interactions, RPM, and transfer of large imaging files require robust infrastructure and high bandwidth that may, at times, be unavailable (Pamplin et al., 2019).

Lack of standards: In addition to resource constraints, gaps in triage standards and preparedness procedures add another layer of complexity in care delivery during disasters regardless of modality (Perkins et al., 2017). Lack of homogenous interactions between the hub and spoke sites could cause many challenges (Alwashmi, 2020). Little to no standardized training on technology makes the learning curve even steeper for healthcare workers and reduces their productivity during a natural disaster (Der-Martirosian et al., 2019; Doarn et al., 2018; French et al., 2020; Radcliff et al., 2018; Langabeer II et al., 2017; Bitterman & Zimmer, 2018).

Technical barriers: Technology presents its own set of unique challenges, including but not limited to the availability of confidential and secure communication lines (Augusterfer et al., 2018). Some devices and equipment are designed for specific environments causing application or device compatibility issues when transferring data or integrating with another system. The high investment and maintenance costs of equipment can also present challenges for many health systems (Pamplin et al., 2019; Chan et al., 2017; Turner et al., 2019).

Telehealth remains unintegrated into many hospitals' EHRs, public health systems, or disaster planning infrastructure (Grover et al., 2020; Crutchfield & Harkey, 2019). When systems are not integrated, patients under distress are asked redundant questions, and the data entry can lead to a more fragmented patient medical record (Grover et al., 2020, Radcliff et al., 2018). Unintegrated systems increase chances for data entry errors and lead to point solutions that may not incorporate a holistic patient-centered view based on their medical history (Elliott & Yopes, 2019).

Providers' low comfort level with technology, their uncertainty about the quality of care through telehealth, lack of training, and limited access to technology experts with clinical understanding have also been significantly contributing to the low telehealth adoption in the U.S. (Elliott & Yopes, 2019; Pamplin et al., 2019; Yuen et al., 2016; Andrews & Quintana, 2015; Kim et al., 2013; Langabeer II et al., 2017).

Federal and state policies: Many studies have noted licensure requirements and reimbursement guidelines as leading causes for lack of progress in telehealth (Elliott & Yopes, 2019; Andrews & Quintana, 2015; Uscher-Pines et al., 2016; Langabeer II et al., 2017). States vary in how they determine commercial and Medicaid reimbursements or the sources of funding available pre- and post-disaster (Pamplin et al., 2019; Andrews & Quintana, 2015). Other complexities concerning security, privacy, malpractice laws, and ambiguities in government and private sectors' roles contribute to the lack of telehealth use nationally (Doarn et al., 2018; Uscher-Pines et al., 2016).

The next section will offer insights into Florida's preparedness for Hurricane Irma to provide a more comprehensive context for our analysis. The discussion will also offer state-level information on the aftermath of the hurricane. A brief overview of Florida's population, the distribution of the health systems, and current state policies will help set the stage for a detailed discussion and interpretation of the data.

2.4 Hurricane Irma in Florida

Hurricane Irma slowed down while heading toward Florida, but it gained strength and became a category four hurricane by the time it made landfall in Cudjoe Key on September 10, 2017. The Florida governor issued his first state of emergency for the Keys' residents on September 4, noting that all Floridians should prepare for possible evacuations. On September 6, as the hurricane was getting near Puerto Rico, mandatory evacuations for six coastal counties in Florida were issued. On September 7, mandatory evacuations were in effect for 24 counties (Table 2), while other counties were encouraged to follow voluntary evacuation notices. By September 10, the entire State of Florida was under a state of emergency. The orders issued by the Florida Governor prompted the largest evacuations in the history of the state and resulted in significant traffic congestions and delays (Team Complete, 2020).

On September 11, Irma moved inland and continued its acceleration toward the state's north and northwestern parts. By the time the storm passed the eastern part of Tampa and headed toward Georgia and Alabama, it had weakened to a category one but maintained an enormous wind field. Florida is only 140 miles wide across its widest part; due to its shifting path, Irma impacted over 85% of Floridians directly or indirectly (NOAA, n.d.; Amadeo, 2019). For the most part, the western panhandle was spared from significant destructions, while the Florida Keys were impacted the most by strong winds and flooding (Amadeo, 2019; Team Complete, 2020).

2.4.1 Hurricane Preparedness

The state and local governments and health systems in Florida have learned substantially from the past decades' recurring hurricanes. Florida has issued many mandatory evacuations over the years, including the areas affected during Hurricane Irma. Officials have created detailed plans with built-in assumptions for various disaster scenarios. The local emergency managers have been trained to help with evacuations and encourage residents to follow the governor’s instructions (Ghose, 2017).

Florida authorities have emphasized pre-disaster training and exercises for the efficient execution of tasks; however, counties' readiness continues to vary. The partnership between counties, the American Red Cross, the Florida National Guard, and numerous health systems helped with evacuations and the critical care delivery across the state (Cava, 2017). At the peak of Hurricane Irma in Florida, approximately 17,567 Guardsmen from 24 states participated in the relief efforts contributing to 1,596 rescues and evacuations (Inserra et al., 2018).

The majority of the response efforts were focused on search and rescue, sheltering operations, support of local law enforcement, air traffic control, evacuation operations, road clearance, and distribution of supplies (Inserra et al., 2018; FEMA, 2018). Approximately 191,764 survivors sought accommodation across 450 of the 700 available shelters. Many residents required immediate medical attention at home, in shelters, or during transport to a medical facility. Irma severely impacted 16% of hospitals across the state (Campo-Flores, De Avila, & Lovett, 2017; FEMA, 2018).

Preparations for Irma also included coordination with electrical companies, preparation of kits, and traffic control on all Florida roads to facilitate evacuations. All 67 Florida counties closed their colleges, universities, and public schools. A list of all 67 counties in Florida, their associated zip codes, and the population in 2017 are outlined in Table 3. Readiness for critical healthcare delivery has remained the primary responsibility of the local healthcare systems.

Hospital preparedness varied across the state. The areas in Irma's direct path, such as the Florida Keys, Monroe County, and stretches across southern Florida, evacuated their patients and closed their facilities. Several facilities across the state prepared to care for patients who could not be evacuated and made arrangements to provide a home for residents without power in the aftermath of the storm. Most facilities that remained open chose to cancel their elective surgeries and divided up their staff to be with onsite or evacuated patients (Vartorella, 2017; ECRI, 2017).

Due to Irma's changing path, evacuation zones and pre- and post-hurricane plans had to shift in real-time. Some nursing homes and assisted living facilities had proactively transported their patients to evacuation zones that happened to be in Irma's shifting path. Assigned personnel had to distribute the patients to available hospitals as they received real-time information about the hurricane's path changes. Some hospitals scheduled mandatory practice runs before the hurricane season to ensure compliance and readiness of their staff. More established facilities with access to resources held in-person and virtual war room meetings to ensure appropriate planning of all departments and personnel (Ginzburg et al., 2018).

2.4.2 Aftermath of Irma in Florida

Hurricane Irma resulted in evacuations of over 6.5 million residents in Florida, and up to 77,000 Floridians chose one of the 450 shelters available to them (Amadeo, 2019). Issa et al. (2018) note that Irma caused 123 deaths in Florida alone; approximately 9% of the deaths were directly related to the hurricane, 89% were indirectly related, and the rest were possibly associated with Irma’s effects. The most common death categories during Irma were linked to exacerbation of existing medical conditions, power outages, and chronic illnesses (Issa et al., 2018). Rolston and Meltzer (2015) indicate that up to 80% of deaths can occur three days after an event. Secondary illnesses from exposure to contamination and post-traumatic distress may increase morbidity and mortality in the weeks after the disaster (Rolston & Meltzer, 2015).

The power was restored slightly faster than in previous years, primarily due to the investments and upgrades in the grid technology and utility poles. However, Florida still required thousands of workers from other states to help with power restoration (Inserra et al., 2018). Because of the upgrades to the power grids, it was easier to install and utilize a record number of generators until the power could be fully reinstated (FEMA, 2018). However, short- and long-term outages still affected many residents in various parts of Florida. Some nursing home patients in Hollywood, Florida, lost their lives after the power loss due to the hurricane. In Irma's aftermath, the nursing home incident forced the local and state officials to seek legislation to protect nursing homes and assisted living facilities by requiring adequate backup power and generators (Cava, 2017).

Approximately seven million households lost power. Many counties were without power for more than ten days after Hurricane Irma made landfall – a critical time for physically, mentally, or socioeconomically vulnerable (FEMA, 2018). The average days without power during Irma were officially reported as 7.5; however, some counties like Monroe or Collier had more prolonged outages. Factors affecting power outages during Irma included the strength of the wind field, type of electricity provider, or socioeconomic factors (Mitsova, 2018; Florida Today, n.d.). The duration of power outages for each county is listed in Table 4.

Within days of Irma making landfall in Florida, most interstate routes and state highways were open, but not all access roads were cleaned up. The debris cleaning continued well into January 2018. In parts of Florida, the most commonly used VA telehealth services offered triage, primary care, and mental health interventions immediately following Irma. The use of VA telehealth during the week after Irma increased from 27% to 50% (Der-Martirosian et al., 2020). The availability of public telehealth data for the state's residents is limited. An available published analysis shows that while the volume of telehealth inquiries increased, top diagnostic categories during and after Irma remained consistent, including acute respiratory illnesses, skin problems, chronic diseases, urinary symptoms, back and joint pains, etc. (Uscher-Pines et al., 2018).

Many hospitals experienced a substantial surge in patients' visits to their EDs during the first week after Irma. After the storm, several evacuated providers could not travel back to their jobs because the roads were not cleared. The inaccessibility of some providers affected the overall readiness of the assigned emergency teams. Some facilities were not adequately prepared with optimal emergency and redundancy plans or needed backup systems. The unpreparedness affected access to needed supplies and disruption in communication lines (FEMA, 2018; Ginzburg et al., 2018).

2.5 Florida Characteristics

2.5.1 Demographics

Florida has the second-longest coastline in the U.S. and is the most populous state after California and Texas. With more than 12% of its 21 million residents living within four feet of high tide, the state has many cities and counties in high-risk areas (Mitsova, 2018). According to the Office of Economic and Demographic Research (EDR) (2020), Florida's long-term population growth has decreased from over 3% per year to 1.77% between 2018 and 2019. The projected population growth is estimated to remain close to 1.5% per year (EDR, 2020). The top seven most populous counties in Florida make up 51.7% of the state's total population. The data published by the Bureau of Economic and Business Research (2019) indicate that 36 counties in Florida have experienced over 5% increase in population over the last decade, with 22 of them having expanded by more than 10% (EDR, 2020; University of Florida, 2019).

The median age of Floridians is estimated to be 41.7 years; seven counties have a median age of 50 and older, including Sumter, Charlotte, Citrus, Sarasota, Highlands, Martin, and Indian River (EDR, 2010). A detailed map of median age distribution by county is included in Figure 3. According to the EDR (2020) data, the net migration and natural population increase are expected to reach 5.6 million by 2030, and over 50% of these gains are in population ages 60 or older.

Florida has become more diverse over the past two decades, and this trend will not change moving forward. While the majority (over 70%) of Floridians are considered White, the percentage of Black and Asian populations has increased. The rate of Hispanics varies throughout the state, with many counties having notable Hispanic population representation, as shown in Figure 4. For example, more than half the Miami-Dade population, Hendry, and Osceola counties are Hispanic (EDR, 2020).

Similar to the ethnic distribution, poverty rates also vary by county in Florida. Out of the 67 counites in Florida, 39 have a poverty rate above the state's 13.7% rate. Many of these counties are in the

Heartland and northern parts and are considered rural. Half of Florida's ten most populated counties also have higher than state poverty rates, as shown in Figure 5 (EDR, 2020). In many parts of Florida affected by Irma and other hurricanes, the vulnerable populations make up six out of ten residents who have difficulties paying for basic essential needs. Many of these individuals suffer long after a natural disaster as their livelihoods vanish, and they will need to find the means to rebuild. Many households would not have access to adequate cash after a hurricane to purchase food and supplies (Cava, 2017).

Over 20% of Floridians are over 65 years of age. Approximately 20% of the population has no access to broadband internet subscriptions. More than 13% of the population currently live in poverty based on the state's census data. As an aging and growing state, Florida faces many challenges, including more significant needs for services and infrastructure provisions. (United States Census Bureau, 2020).

In 2017, approximately 40% of Floridians had insurance coverage through employers and 2% from the military; 17% were Medicare recipients, 19% were Medicaid beneficiaries, and 13% remained uninsured (KFF, 2020). Among the uninsured population, 25% live below the federal poverty level. A recent Kaiser Family Foundation (KFF) report (2019) suggests Florida is in the top four states that will have 19% of its total population soon become eligible for Medicaid. The percentage of individuals under 65 without health insurance has increased to over 16% (United States Census Bureau, 2020).

2.5.2 Healthcare Delivery Systems

According to the American Hospital Directory (2020), there are approximately 320 hospitals in Florida. The data suggest 251 facilities are designated as acute care hospitals, including eight freestanding EDs across six counties. Nineteen facilities are listed as long-term acute care and inpatient rehabilitation facilities, and 26 locations have rural hospital designations (Florida Department of Health, 2018).

Approximately 15 counties, mainly across the panhandle, appear to have no acute care hospitals, and 13 counties only have one (American Hospital Directory, 2020). The data also suggest that there were at least five hospital closures over the past two decades in Florida. In general, counties with less than 20,000 residents appear not to have a long-term acute care hospital; however, in few more populous counties such as Sumter and Wakulla, they also lack the necessary care delivery infrastructure (American

Hospital Directory, 2020). More information on population per county, urban versus rural designation, and hospital availability across the state is included in Table 5 and Figure 6.

According to the National Association of Community Health Centers (2019), there are over 47 federally funded health center organizations and 608 health center delivery sites in Florida. These sites receive over $230 million in federal investments to serve approximately 1.5 million patients. On average 36% of patients served in these health centers are uninsured, and 39% are Medicaid beneficiaries (NACHC, 2019). A map of the community health centers and their delivery sites in Florida (as depicted in Figure 7) shows a high concentration of health centers along the more populous coastline. Health centers' operations will be profoundly affected or even halted significantly during and after severe hurricanes (NACHC, 2019). Medicaid policies are significantly associated with health centers' adoption of telehealth. The states that face more Medicaid policy barriers negatively associate with telehealth adoption (Lin et al., 2018).

2.5.3 Policies and Regulation

Floridians benefit from many federal policies that are enforced at a national level. A portion of these policies' monetary benefits is allocated toward search and rescue efforts or critical care delivery in disaster zones. The 1974 Emergency Medical Services Systems Act was designed to ensure states and localities can receive the necessary assistance in developing coordinated emergency medical service systems. Later in 1988, the Act was amended with the Robert T. Stafford Disaster Relief and Emergency Assistance Act to incorporate a high number of disasters that would fall under the broader umbrella definition of federal disasters (Longest, 2016; Homeland Security Digital Library, n.d.). In 1985, the Emergency Medical Treatment and Labor Act (EMTALA) was signed into law requiring hospitals that participated in Medicare to have active emergency rooms and provide appropriate medical and stabilizing treatments. EMTALA has provided significant value in ensuring hospital preparedness for natural disasters in states like Florida (Longest, 2016).

Over the past two decades, the Florida Legislature (2020) has collaborated on and dismissed several disaster-relief bills in the Florida Senate that could have better prepared the state for hurricanes. A review of what has passed in the Florida Senate over the past two decades to support disaster reliefs shows mostly budget appropriations but no policy changes. Even after Hurricane Irma, the 2018 SB 1006 for Disaster Response and Preparedness in favor of a comprehensive emergency management plan, public awareness programs, registry for homeless shelters, and local colleges and agencies' participation did not pass in the Florida Senate (The Florida Senate, 2020).

The Center for Connected Health Policy report (2019) highlights recently added telehealth legislation for private payers in Florida, indicating that service parity must be mutually agreed upon between insurers and providers. Any differences in payment between in-person and virtual services can exist if contractually agreed to between the insurers and telehealth providers. HB 23 was designed to bypass payment parity and was approved in the Senate and sent to Governor DeSantis for a signature to go into effect starting July 1, 2019. Subsequently, Florida's Board of Medicine abolished its telehealth guidelines in light of the new legislation (Wicklund, 2019).

The new HB 23 law put forth includes asynchronous or store-and-forward communication but not audio-only phone calls, emails, or faxes. The law also offers a framework to help providers in using telehealth and mHealth modalities. The law further includes a loophole for out-of-state physicians to bypass licensing fees, whereby the cost is absorbed by in-state providers (Wicklund, 2019). Additionally, online prescription of drugs doesn't require a provider to access a patient's medical history as long as the virtual visit allows for evaluation and diagnosis. While the online prescription of controlled substances is not permitted, there are exceptions for inpatient treatments, hospices, and skilled nursing facilities (Center for Connected Health Policy, 2019).

In March 2020, Florida's surgeon general issued an Emergency Order in response to the outbreak of COVID-19 in the state. The order allowed for certain Florida licensed physicians to use telehealth services in place of office visits. The order further allowed out-of-state physicians not licensed in Florida to provide healthcare services for up to 30 days unless the public health emergency status is extended by the state's surgeon general. An exemption in this order allowed physicians with clear standing who hold unrestricted licenses to practice in the state and for other licensed advance providers to issue prescription renewals. The Public Health Emergency (PHE) Order was extended a few times throughout 2020 to mitigate the effects of COVID-19 but it is unclear whether any of these changes will be put into effect permanently (Federation of State Medical Boards, 2021).

Florida follows the federal guidelines for Medicare regulations; however, its Medicaid program is administered by the Florida Department of Children and Families. Florida is also one of the 14 states that have not expanded its Medicaid benefits. The Medicaid coverage expansion under the Affordable Care Act (ACA) would provide insurance coverage to over 800,000 Floridians, representing 30% of the state's uninsured population (KFF, 2020). A map depicting the areas where the uninsured population lives across the state is included in Figure 8.

Florida's 2019 Medicaid program updates for telehealth include reimbursements for real-time interactive, two-way video conversations that use the appropriate administrative codes. Currently, the eligible services include Child Protective Team (CPT) and Community Behavioral Health Services. The state allows the use of telehealth by all providers registered in the Florida Medicaid services program. Store-and-forward or RPM are not currently reimbursed through the Florida Medicaid Program (Center for Connected Health Policy, 2019). It is unclear how the recent definitions of telehealth in HB 23 may affect Medicaid laws in the long-term.

Two more recent regulatory changes included the introduction of HB 21 that went into effect starting July 2019. This Florida Senate bill addresses the 'certificate of need' (CON) regulatory process that has required hospitals to obtain state approval before building facilities or adding tertiary services. HB 21 eliminates the need for state approvals moving forward. The second legislation, SB 322, allows the sale of short-term health insurance policies that can be offered as a scaled-back option to counter the federal ACA mandate currently available in most states. The bill requires insurance companies to sell coverage to people regardless of pre-existing medical conditions. SB 322 is designed to provide an option if ACA is struck down by the United States Supreme Court (Sexton & Saunders, 2019).

CHAPTER III: METHODOLOGY

3.1 Research Design

A retrospective descriptive quantitative analysis of ED visits was conducted using archival billing data. The use of deidentified 2017 archival billing data obtained through the Medical University of South Carolina (MUSC) eliminated the need for Institutional Review Board (IRB) approvals, reduced the study's cost, and excluded the challenges with low response rate. This research was designed to establish a baseline for ED utilization in identified Florida counties. A comparison of the baseline with variations reflected in the data during and after the hurricane would provide insights into potential trend changes in ED utilization. The New York University (NYU) ED algorithm was utilized to classify the visits into distinct emergent versus non-emergent categories to evaluate which visits could potentially be treated remotely using telehealth. The insights were used to recommend ways to serve the population affected by natural disasters with better care while considering cost implications.

3.2 Research Questions

This project explored three specific research questions:

1. What were the dynamics of ED care visits before and after Hurricane Irma?
   a) What proportion of and where did patients living in counties under mandatory evacuations seek ED care pre- and post-hurricane?
   b) What proportion of and where did patients affected by extended power outage seek ED care pre- and post-hurricane?
2. What variations in volume and type of ED visits did we see in patients?
   a) What variations in care-seeking volume did we see pre- versus during the quarter of hurricane landfall (Q2 versus Q3) between in-county visits and out-of-county visits and between emergent and non-emergent visit types in counties affected by mandatory evacuation orders?
   b) What variations in care-seeking volume did we see during the quarter of hurricane landfall versus post-hurricane (Q3 versus Q4) between in-county visits and out-of-

county visits and between emergent and non-emergent visit types in counties affected by extended power outages?

3. How many and what types of care may be served using telehealth leading to potential cost savings?

3.4 Sample Selection

Individual-level data was used to address the research questions and characterize ED visits tendency and variability before and after Hurricane Irma. Patients between 0-99 years of age of all demographics and chief complaints seeking care in ED were included in the analysis regardless of whether the hurricane caused their injuries. While most of the investigation was conducted at the individual level, the project also contained county-level variables to identify patients' county of residence versus the ED location.

Payor mix, ED care charges, and payments were included in variables of interest; these variables were used for comparisons and discussion of ways to offer alternative care options. Factors, such as unique local or environmental issues causing a surge in ED visits before the hurricane, could not be identified and controlled and may have affected the findings.

3.5 Instrumentation

This retrospective quantitative analysis used the Healthcare Cost and Utilization Project (HCUP) database sponsored by the Agency for Healthcare Research and Quality (AHRQ). AHRQ is a federal agency charged to develop tools and data supporting improving the country's safety and quality of care. The agency collects available national- and state-organized, hospital associations, and private organizations' data and provides them in a consumer-friendly format for further analysis (AHRQ, 2018).

HCUP incorporates the most extensive collection of statistical briefs in the country. HCUP statistics provide insights into various areas such as length and cost of hospital stays, adverse events, etc. One of the HCUP resources available includes the State Emergency Department Databases (SEDD) from collaborating states. SEDD is presented as a set of longitudinal data that capture discharge information for

ED visits that do not result in an admission. The Florida SEDD data was used for this analysis (AHRQ, 2018).

The NYU ED Algorithm (EDA) was also utilized to classify the visits into two distinct categories.

- **Non-emergent (NE):** Visits that don't need immediate medical care for 12-hours;
- **Emergent:** All other visits that include primary care treatable, preventable/avoidable, and non-preventable.

The NYU EDA is claims-based and helped in evaluating which ED visits could have potentially been treated remotely using telehealth. The algorithm is designed to correspond to specific International Classification of Diseases 10th Revision (ICD-10) codes for ED visits and includes assigned probability for each diagnosis code (NYU Wagner, n.d.; HDMS, 2017). ICD-10 codes are used worldwide for diagnostic and procedural coding to facilitate recording, analysis, interpretation, and critical data comparison. ICD-10 external cause of injury codes (e-codes) are used to codify the mechanism and cause of injury (CDC, 2015).

Every ED visit in 2017 by residents of Florida was assigned a binary value indicating receipt of care in their county of residence or in a county outside their residential area (In-county=1 if a local ED is used; In-county=0 if ED outside of local service area is used). This variable was constructed using data from the second quarter of 2017 to reflect non-hurricane conditions. We assigned a value of 1 to all ED visits to:

- Hospitals with the same county code as the patient's residence;
- If hospital market areas overlapped counties such as Miami-Dade and Broward counties;
- If the hospital market area for >70% of ED visits included the county, and the county accounted for a minimum of 5% of the hospital's ED visits.

Thus, a county may be served by one or more hospitals which are designated "local" or "In-county" in this analysis. This approach allowed us to correctly assign a "local" designation for ED visits in the metropolitan counties where hospital market areas overlap counties.

3.6 Data Set Description

This analysis focused on a comparison of pre-hurricane ED utilization and post-event behaviors. We established pre- and post-storm indicators to help identify displaced residents' health care choices. HCUP data for the State of Florida do not include exact treatment dates but are identified by quarters. Hence, the analysis was designed to set the pre-and post-hurricane timelines based on quarters. While the actual dates that delineate the hurricane are listed here, the study was limited to a broader definition of time.

- **Duration of Hurricane Irma in Florida:** September 10th and 11th, 2017
- **Hurricane Time:** May 1 through September 30, 2017 (3rd Quarter)

Study time periods:

- **Pre-hurricane time:** April 1 through June 30, 2017 (2nd Quarter)
- **Post-hurricane time:** October 1 through December 31, 2017 (4th Quarter)

Comparison county groups that are most likely to be adversely affected by the hurricane:

- **Mandatory Evacuation Counties**: Mandatory evacuation orders are considered pre-storm drivers that were in effect for 24 counties, as highlighted in Table 6.
- **High Power Outage Counties:** Post-storm power outages are lagging indicators that happen during and after the hurricane. The average days of power outage were 7.2, as indicated by the officials in Florida (Mitsova, 2018). This analysis will examine the ED utilization for all counties with a maximum power outage of eight days or more, as shown in Table 7.

We examined the data by age group, sex, race, and payor type closely mapped to the characteristics defined in the HCUP database for ED visits and the study conducted by Ballard et al. (2010) for application of NYU EDA (see Table 8).

3.7 Data Analysis

The statistical data analysis was conducted using SAS version 9.4 software. Counts and percentages of visits were estimated to assess the impact of time (pre- versus post-hurricane) and location (evacuation versus no evacuation counties and high versus low power outage counties). The categorical data comparisons were performed using the chi-square test; t-test was used to compare continuous data during pre-and post-hurricane time periods and between people living in affected versus unaffected counties. Statistical significance across all analyses was defined as $p<0.05$.

The analysis describes patient characteristics, age group, sex, and payor type for all ED visits in counties with mandatory evacuations and those with extended power outages during the second quarter (Tables 6 and 7). A comparison was drawn for total ED visits and emergent versus non-emergent types before, during, and after the hurricane by comparing the same variables from the second to the third quarter and then from the fourth to third quarter. The analysis also highlights variability in evacuees' behavior in seeking ED care outside of their county of residence by examining a collection of primary counties of interest and mapping any changes in the proportion of ED visits in in- versus out-of-county pre- and post-hurricane.

The analysis includes considerations for the potential severity of patients' conditions; hence, only NE codes specified in the NYU EDA methodology as having < 50% probability of needing emergent services were regarded as telehealth intervention options. During a natural disaster, many non-emergent or low-acuity emergent conditions may not be appropriate to be addressed remotely through telehealth. Within the Non-emergent NYU group, only ED visits with the Current Procedural Terminology (CPT) billing codes indicating that "the presenting problem is self-limiting or minor" (CPT 99281, 99282, 99283) were considered to be relevant for telehealth or other virtual care modalities.

This examination provides insights into high-level assessments of potential cost savings using telehealth by assigning standard cost weights of ED versus telehealth visits to the proportion of individuals who could have avoided ED care during the comparison time periods. The 2017 Florida HCUP data records included ED total charges and cost-to-charge ratios for >90% of the state's EDs. However, costs of care to patients or insurers will be somewhere between the estimated cost to the hospital and the total billed charges. We estimated an "expected payment" per visit using a charge-to-payment-ratio (CTPR) which was calculated for specific payer groups (Simpson & Simpson, 2018). The

CTPR used included Private Payers 40% of charges, Medicare and Other payers 25% of charges, and Medicaid 15% of charges.

The expected payment for each ED visit was calculated as charges multiplied by CTPR, resulting in a payment estimate uniquely reflecting the resources used for each visit. Since cost data are not available for “potential virtual visits”, we used CPT codes for new patients for visits with similar severity as the codes used for the ED visits. Thus, an ED visit with a CPT code of 99281 was assigned the value of an urgent care visit with a CPT code of 99202 as reported for the 50% percentile of “Usual, Customary, and Reasonable” (UCR) rates and Medicare fees reported for the US; similarly, ED CPT 99282 was set to CPT 99203, and ED CPT 99283 to CPT 99204 (Davis, 2016).

CHAPTER IV: RESULTS

Research Question 1A

What proportion of and where did patients living in counties under mandatory evacuations seek ED care pre- and post-hurricane?

From the 24 counties under mandatory evacuations, four were designated as Rural and the rest Urban. The overall comparison of the total numbers of in-county ED visits remained relatively consistent across the second and third quarters for most of these counties, as displayed in Table 9. No other unique patterns were identified among more or less populous counties. However, three counties had a larger drop (≥3%) in in-county ED visits in Q3 compared to the baseline (Q2). These counties included Monroe (Rural), Seminole (Urban), and Sumter (Urban). Only Monroe and Sumter Counties were in the direct path of Hurricane Irma in September. In Monroe County, many facilities evacuated patients before Hurricane Irma made landfall or even closed their doors and split medical staff to ensure some could stay with evacuated patients.

Table 9: Florida Residents' Use of In-County ED Services in Counties under Mandatory Evacuations.

County	Population	Q2 In-county visit (% of total in-county visits)	Q3 In-county visit (% of total in-county visits)	Designation
Brevard	587,769	39,730 (81.6)	39,286 (82.2)	Urban
Broward	1,934,516	132,792 (71.3)	126,605 (70.7)	Urban
Citrus	145,415	10,992 (73.1)	10,739 (73.5)	Urban
Collier	372,678	17,080 (90.1)	15,676 (88.7)	Urban
Dixie	16,615	1,330 (89.2)	1,570 (90.6)	Rural
Duval	937,933	84,239 (80.1)	82,403 (80.4)	Urban
Flagler	109,999	7,385 (75.1)	7,278 (74.7)	Urban
Glades	13,580	521 (69.7)	434 (70.3)	Rural
Hendry	41,018	3,166 (55.6)	2,820 (55.9)	Rural
Hernando	186,704	16,563 (89.1)	16,784 (89.5)	Urban
Indian River	154,241	13,622 (90.5)	12,523 (89.3)	Urban
Lee	740,000	47,156 (84.3)	46,012 (84.2)	Urban
Martin	159,701	8,927 (80.6)	8,593 (81.1)	Urban
Miami-Dade	2,713,295	159,096 (70.4)	149,561 (68.8)	Urban
Monroe	76,483	4,951 (84.9)	5,229 (78.8)	Rural
Orange	1,355,921	99,641 (75.8)	97,079 (75.8)	Urban
Palm Beach	1,470,344	110,924 (95.5)	104,528 (95.3)	Urban
Pasco	525,141	30,087 (70.5)	30,384 (70.6)	Urban
Pinellas	968,341	61,166 (65.9)	60,835 (66.2)	Urban
Sarasota	419,680	25,640 (78.5)	24,597 (86.3)	Urban

Seminole	462,801	26,335 (86.7)	25,902 (78.8)	Urban
St. Lucie	313,163	29,193 (91.6)	27,796 (91.1)	Urban
Sumter	124,995	2,040 (39.3)	1,891 (36.3)	Urban
Volusia	537,868	48,210 (78.5)	48,207 (79.3)	Urban
Total	**14,368,201**	**980,786 (77.8)**	**946,732 (77.4)**	

A closer analysis of Monroe, Seminole, and Sumter Counties indicated that a total of 11,680 ED visits in Q3 were received outside of residents' service areas. Only 11 counties provided care to >1% of the population of those three counties. As shown in Table 10, the largest destination for out-of-county care delivery was Orange County which accounted for 49% of the Q3 ED visits outside of Monroe, Sumter, and Seminole service areas. Orange County (Urban) is among the counties in Florida with higher number of acute care facilities. Miami-Dade and Marion Counties were the second and third most popular destinations, and accepted approximately 6.8% and 6.7% of out-of-service area visits from these three counties (Figure 9). Monroe County was under mandatory evacuation and also experienced prolonged power outages starting in Q3. While Sumter County service area presented a very low concentration of acute facilities, the EDs in the region actually provided nearly 6% of out-of-area care delivery for patients living in Monroe and Seminole Counties.

Table 10: Number and Percent of Out-of-County ED Visits for Residents of Monroe, Seminole, and Sumter Counties During Q3, 2017 (excluding visits with missing county identifiers for a hospital).

Destination County	Frequency of Q3 Out-of-County ED Visits	Percentage of Total Q3 Out-of-County ED Visits
Alachua	122	1.04
Bay	<11	-
Bradford	<11	-
Brevard	98	0.84
Broward	178	1.52
Charlotte	12	0.10
Citrus	769	6.58
Clay	15	0.13
Collier	17	0.15
Columbia	13	0.11
DeSoto	<11	-
Duval	93	0.80
Escambia	13	0.11
Flagler	<11	-
Franklin	<11	-
Hendry	<11	-
Hernando	298	2.55
Highlands	24	0.21

Hillsborough	129	1.10
Holmes	<11	-
Indian River	13	0.11
Jackson	15	0.13
Lake	17	0.15
Lee	34	0.29
Leon	63	0.54
Levy	<11	-
Madison	<11	-
Marion	781	6.69
Martin	23	0.20
Miami-Dade	795	6.81
Monroe	<11	-
Nassau	<11	-
Okaloosa	<11	-
Okeechobee	<11	-
Orange	5,750	49.23
Osceola	113	0.97
Palm Beach	115	0.98
Pasco	587	5.03
Pinellas	104	0.89
Polk	79	0.68
Putnam	<11	-
Santa Rosa	<11	-
Sarasota	35	0.30
Seminole	18	0.15
St. Johns	25	0.21
St. Lucie	28	0.24
Sumter	687	5.88
Suwannee	<11	-
Taylor	<11	-
Volusia	533	4.56
Walton	<11	-

The descriptive statistics of in-county ED visits for counties under mandatory evacuations indicated that the overall number of visits declined slightly in Q3 versus Q2; the finding was in line with the reports of many facilities closing and evacuating patients before Irma made landfall in Florida. Overall, more White and female patients referred for in-county ED visits during both quarters. The proportion of other ethnicities and the mean age remained consistent across both quarters, as displayed in Table 11.

While the majority of patients using in-county ED visits were Medicaid beneficiaries followed by Private, Other, and Medicare patients, there was more than a 1% drop in the overall inquiries of Medicaid patients and a 1% increase in Medicare and Other payors in Q3 compared to Q2. The increase in percent Medicare claims may correspond to the increase in claims among White patients who represent the majority of Medicare beneficiaries, however it doesn't fully explain the change. In general, Medicare beneficiaries are frail and have multiple comorbidities that require immediate attention from Primary Care Physicians (PCPs) or in EDs. The small decrease in percent Medicaid claims may reflect the slowing trend in the overall monthly Medicaid enrollments in Florida in 2017 starting in Q2. However, many Medicaid beneficiaries tend to be younger and may choose to delay seeking care with PCPs or at EDs before or during a natural disaster (Table 11).

Table 11: Descriptive Statistics of In-county ED Visit for Counties with Mandatory Evacuations.

		Mandatory Evacuations	
		Q2	**Q3**
N (%)		980,786 (77.8)	946,732 (77.4)
Sex (%)	**Female**	652,534 (57.4)	537,391 (56.7)
	Male	418,248 (42.6)	409,339 (43.3)
Race (%)	**Black**	290,425 (29.6)	276,060 (29.1)
	Hispanic	229,039 (23.4)	218,533 (23.1)
	Other	33,257 (3.4)	30,960 (3.3)
	White	428,065 (43.6)	421,179 (44.5)
Mean Age (SD)		36.6 (24.1)	37.8 (24.0)
Payor Type (% of total claims)	**Medicaid**	340,264 (34.7)	313,005 (33.1)
	Medicare	181,781 (18.5)	184,501 (19.5)
	Other	212,302 (21.7)	216,059 (22.8)
	Private	246,439 (25.1)	233,167 (24.6)

Research Question 1B

What proportion of and where did patients affected by extended power outage seek ED care pre- and post-hurricane?

A total of 42 counties in Florida experienced extended power outages (>8 days) during and after the hurricane; 14 of those counties were designated as Rural. The rural counties experienced on average over 80% power outage during Q3 and some even in early Q4. The overall numbers of ED visits increased during Q4 after Irma had made landfall. The data in Table 12 indicate that the proportion of ED visits at the county-level remained consistent when comparing Q3 and Q4. Noteworthy were three urban counties that provided in-county care to less than 65% of their overall residents in Q4; these counties included Polk, St. Johns, and Sumter. Polk and Sumter Counties were directly in the path of Hurricane Irma, while St. Johns was not as much affected by severe rain and wind gusts. Out of these three counties, Sumter was the only one also affected by mandatory evacuation orders in Q3.

Table 12: Florida Residents' Use of In-County ED Services in Counties with Extended Power Outages.

County	2017 Population	Q3 In-county visit (% of total in-county visits)	Q4 In-county visit (% of total in-county visits)	Designation	% Power Outage at Peak
Alachua	266,309	25,473 (94.5)	26,037 (94.3)	Urban	53%
Baker	28,254	2,716 (76.7)	2,761 (75.3)	Rural	94%
Bradford	27,142	3,113 (63.7)	3,002 (70.2)	Rural	95%
Brevard	587,769	39,286 (82.2)	40,996 (81.9)	Urban	86%
Broward	1,934,516	126,605 (70.7)	132,929 (71.4)	Urban	76%
Charlotte	181,522	12,570 (85.3)	13,705 (86.5)	Urban	64%
Citrus	145,415	10,739 (73.5)	11,384 (74.4)	Urban	79%
Collier	372,678	15,676 (88.7)	17,896 (90.7)	Urban	96%
Columbia	69,999	10,386 (87.0)	10,715 (87.1)	Urban	92%
DeSoto	37,241	2,837 (75.4)	3,336 (74.4)	Rural	89%
Dixie	16,615	1,570 (90.6)	1,544 (90.7)	Rural	75%
Flagler	109,999	7,278 (74.7)	7,825 (75.2)	Urban	91%
Gilchrist	17,900	1,490 (90.9)	1,488 (92.2)	Rural	79%
Glades	13,580	434 (70.3)	536 (75.4)	Rural	67%
Hardee	27,154	2,902 (72.5)	3,036 (72.9)	Rural	97%
Hendry	41,018	2,820 (55.9)	3,132 (56.1)	Rural	100%
Hernando	186,704	16,784 (89.5)	17,061 (89.4)	Urban	62%
Highlands	103,852	11,669 (93.8)	12,605 (94.2)	Urban	100%
Lafayette	8,602	482 (65.0)	483 (66.2)	Rural	91%
Lake	345,432	26,416 (81.9)	27,197 (81.7)	Urban	70%
Lee	740,000	46,012 (84.2)	50,365 (85.4)	Urban	82%
Levy	40,276	3,738 (82.0)	3,718 (83.2)	Rural	73%
Madison	18,474	2,017 (73.4)	2,022 (75.0)	Rural	67%
Manatee	385,506	21,424 (80.6)	23,574 (80.3)	Urban	63%
Marion	353,339	28,485 (89.1)	30,402 (89.9)	Urban	76%
Miami Dade	2,713,295	149,561 (68.8)	160,880 (70.8)	Urban	81%
Monroe	76,483	5,229 (78.8)	5,739 (84.6)	Rural	85%
Nassau	82,925	6,693 (90.9)	6,618 (91.5)	Urban	98%
Okeechobee	41,275	5,423 (84.3)	5,474 (85.4)	Rural	96%
Orange	1,355,921	97,079 (75.8)	103,738 (75.9)	Urban	62%
Osceola	353,623	19,270 (68.3)	21,202 (69.6)	Urban	43%
Palm Beach	1,470,344	104,528 (95.3)	110,884 (95.5)	Urban	74%

Pinellas	968,341	60,835 (66.2)	62,643 (66.5)	Urban	79%
Polk	685,368	50,294 (63.7)	55,164 (63.9)	Urban	66%
Putnam	73,384	9,222 (75.1)	9,658 (75.6)	Urban	89%
St. Johns	243,693	9,285 (64.7)	9,028 (62.7)	Urban	100%
Sarasota	419,680	24,597 (86.3)	26,065 (86.7)	Urban	66%
Seminole	462,801	25,902 (78.8)	27,363 (79.3)	Urban	93%
Sumter	124,995	1,891 (36.3)	1,848 (35.1)	Urban	39%
Suwannee	44,124	5,664 (81.9)	5,677 (80.9)	Rural	92%
Volusia	537,868	48,207 (79.3)	51,384 (81.9)	Urban	78%
Wakulla	32,050	2,966 (96.4)	2,889 (96.6)	Rural	74%
Total	**15,745,466**	**1,049,568 (78.4)**	**1,114,003 (78.9)**		

A closer look at Polk, St. Johns, and Sumter Counties indicated that a total of 39,850 ED visits in Q4 were received outside of residents' service areas. Of these only 10 counties provided care to >1% of the population of the three counties. As shown in Table 13, the most popular destinations for out-of-county care delivery were Polk, Duval and Hillsborough Counties. While Polk County service area didn't offer a large number of acute facilities and saw a drop in in-county visits, it still accounted for 57% of Q4 ED visits among individuals living in St. Johns and Sumter Counties who travelled out-of-county for care. Duval and Hillsborough Counties served 11% and 8% of the residents of the three counties respectively. Duval County is in closer proximity to St. Johns, and Hillsborough is easily accessible by residents of Polk and Sumter Counties (Figure 10). Both Duval and Hillsborough were among the counties in Florida that offer a larger concentration of acute care facilities.

Table 13: Number and Percent of Out-of-County ED Visits for Residents of Polk, St. Johns, and Sumter Counties During Q4, 2017 (excluding visits with missing county identifiers for a hospital).

Destination County	Frequency of Q4 Out-of-County ED Visits	Percentage of Total Q4 Out-of-County ED Visits
Alachua	206	0.52
Baker	<11	-
Bay	18	0.05
Bradford	13	0.03
Brevard	38	0.10
Broward	104	0.26
Charlotte	14	0.04
Citrus	727	1.82
Clay	118	0.30
Collier	12	0.03
Columbia	25	0.06
DeSoto	<11	-
Duval	4,632	11.62
Escambia	16	0.04

Flagler	96	0.24
Franklin	<11	-
Hardee	159	0.40
Hendry	<11	-
Hernando	329	0.83
Highlands	769	1.93
Hillsborough	3,277	8.22
Holmes	<11	-
Indian River	22	0.06
Jackson	<11	-
Lake	17	0.04
Lee	41	0.10
Leon	104	0.26
Levy	<11	-
Madison	<11	-
Manatee	27	0.07
Marion	928	2.33
Martin	<11	-
Miami-Dade	86	0.22
Monroe	16	0.04
Nassau	17	0.04
Okaloosa	<11	-
Okeechobee	11	0.03
Orange	1,856	4.66
Osceola	897	2.25
Palm Beach	97	0.24
Pasco	919	2.31
Pinellas	257	0.64
Polk	22,809	57.24
Putnam	172	0.43
Santa Rosa	<11	-
Sarasota	64	0.16
Seminole	24	0.06
St. Johns	21	0.05
St. Lucie	18	0.05
Sumter	698	1.75
Suwannee	<11	-
Taylor	<11	-
Union	<11	-
Volusia	136	0.34

The descriptive statistics of the 42 counties with extended power outages indicated that more White and female patients received in-county ED visits during Q3 and Q4 followed by Black, Hispanic and other races. It is noteworthy that the percentage of White patients needing in-county ED visits in Q4 decreased by 1.4% compared to Q3, while there was an increase of 1.3% among Hispanic patients in the same period. The mean age remained consistent across both quarters, as depicted in Table 14.

Medicaid visits made up the majority of patient needs in both quarters followed by Private, Other, and Medicare beneficiaries. The proportion of ED visits remained relatively consistent in Q3 and Q4, however, there was a 1.3% increase in Medicaid claims in Q4 compared to Q3, while Other and Medicare claims saw a 0.4% decrease each during the same period.

The slight drop in percent Medicare claims may correspond to the percent decrease in claims among White patients who represent the majority of Medicare beneficiaries; these patients may have sought care a quarter earlier. Hispanic population concentration is high in the counties with extended power outages and this group represents a significant portion of the overall Medicaid beneficiaries in Florida. The 1.3% increase in Hispanic patient population visits in Q4 may correspond to the increasing percentage in the Medicaid claims during the same quarter. The increase may also point to a pent-up demand created due to postponement in seeking care among this group earlier in the year when hurricane season became more active in Florida (Table 14).

Table 14: Descriptive Statistics of In-county ED Visits for Counties with Extended Power Outages.

		Extended Power Outage	
		Q3	**Q4**
N (%)		1,049,568 (78.4)	1,114,003 (78.9)
Sex (%)	**Female**	597,041 (56.9)	639,184 (57.4)
	Male	452,524 (43.1)	474,817 (42.6)
Race (%)	**Black**	273,845 (26.1)	289,637 (26.0)
	Hispanic	244,734 (23.3)	273,768 (24.6)
	Other	31,814 (3.0)	36,106 (3.2)
	White	499,175 (47.6)	514,492 (46.2)
Mean Age (SD)		37.3 (24.0)	37.1 (24.7)
Payor Type (% of total claims)	**Medicaid**	342,978 (32.7)	378,340 (34.0)
	Medicare	212,031(20.2)	220,424 (19.8)
	Other	234,069 (22.3)	244,241 (21.9)
	Private	260,490 (24.8)	270,998 (24.3)

Research Question 2A

What variations in care-seeking volume did we see pre- versus during the quarter of hurricane landfall (Q2 versus Q3) between in-county visits and out-of-county visits and between emergent and non-emergent visit types in counties affected by mandatory evacuation orders?

Figures 11 and 12 show the percent variations in emergent and non-emergent ED visits in counties with mandatory evacuations between Q2 and Q3. The number and proportion of emergent and non-emergent visits visually appeared to remain relatively consistent in Q2 and Q3, however, the chi-square analysis indicated a statistically significant difference in proportions between quarters for both in- ($p < .0001$) (Figure 11) and out-of-county ($p = .0003$) (Figure 12), and similarly within emergent and non-emergent categories (Table 15).

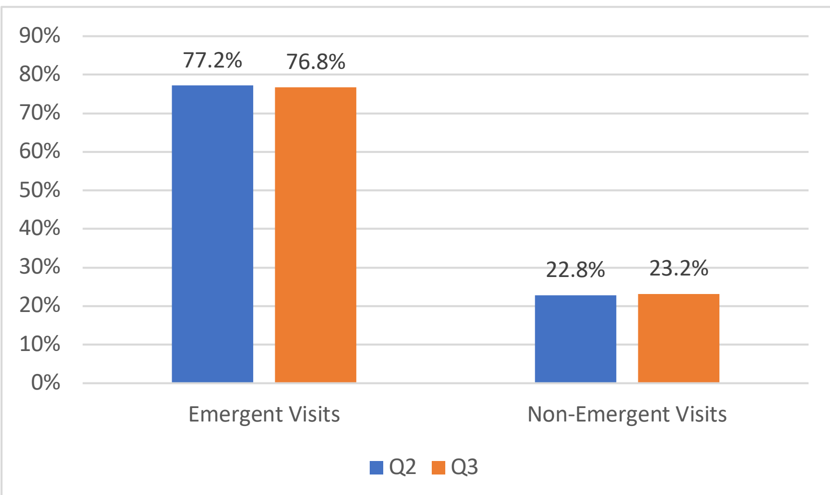

Figure 11: Percent of In-County Emergent and Non-Emergent ED Visits in Counties under Mandatory Evacuations by Quarter.

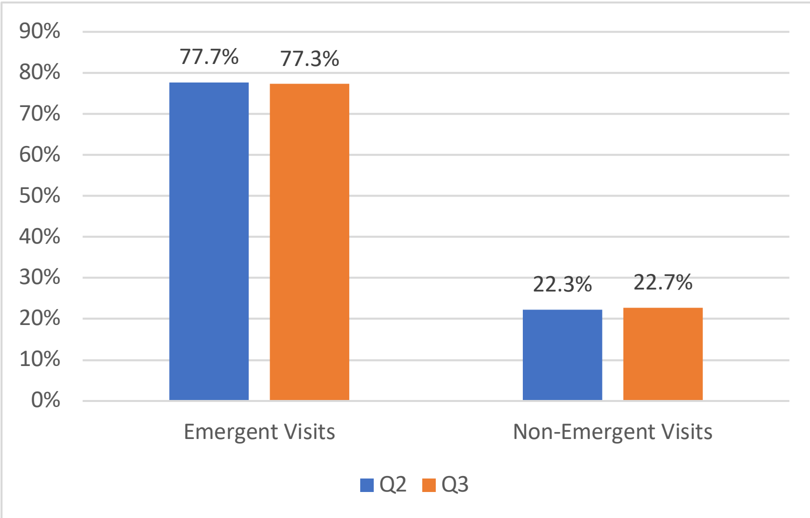

Figure 12: Percent of Out-of-County Emergent and Non-Emergent ED Visits in Counties under Mandatory Evacuations between Q2 and Q3.

Table 15: Frequency of Emergent and Non-Emergent ED Visits in Counties under Mandatory Evacuations between In- and Out-of-County and Q2 and Q3.

Visit Type and Location	Q2	Q3	% diff	p-value
Emergent in-county Visits (%)	757,052 (77.2)	735,422 (76.8)	-0.4%	<.0001
Emergent out-of-county Visits (%)	223,797 (22.8)	222,379 (23.2)	0.4%	
Non-Emergent in-county Visits (%)	223,734 (77.7)	211,310 (77.3)	-0.4%	p=.0003
Non-Emergent out-of-county Visits (%)	64,278 (22.3)	62,131 (22.7)	0.4%	

When examining differences in non-emergent visits between Q2 and Q3, both in- and out-of-county and between evacuation and non-evacuation, there was a statistically significant change between in-county visits, with the proportion of ED visits in evacuation counties decreasing from 51.4% to 48.6% from Q2 to Q3 ($p<0.0001$). However, this trend was not found within out-of-county visits where the proportions did not change between the quarters (50.8% versus 49.1% among evacuation counties in Q2 and Q3 respectively, $p=0.3256$) (Table 16).

Table 16: Frequency of Non-Emergent ED Visits in Counties with and without Mandatory Evacuations between Q2 and Q3.

Visit Type and Location	Q2	Q3	% diff	p-value
In-County Visits – Evacuation Counties (%)	223,734 (51.4)	211,310 (48.6)	-2.8%	

In-County Visits – Non- Evacuation Counties (%)	118,663 (50.8)	115,014 (49.2)	-1.6%	<0.0001
Out-of-County ED Visits - Evacuation Counties (%)	64,278 (50.8)	62,131 (49.1)	-1.7%	0.3256
Out-of-County ED Visits – Non-Evacuation Counties (%)	28,751 (50.6)	28,068 (49.4)	-1.2%	

Research Question 2B

What variations in care-seeking volume did we see during the quarter of hurricane landfall versus post-hurricane (Q3 versus Q4) between in-county visits and out-of-county visits and between emergent and non-emergent visit types in counties affected by extended power outages?

A similar frequency comparison for counties with extended power outages showed the variations in in- and out-of-county ED visits (Figures 13 and 14, respectively). The number and proportion of emergent and non-emergent visits appeared to remain relatively consistent in Q3 and Q4, however, the frequency analysis indicated statistically significant difference (p <.0001, for both emergent and non-emergent) for in- versus out-of-county visits, with in-county ED visits increasing from Q3 to Q4 and out-of-county ED visits decreasing from Q3 to Q4 for both emergent and non-emergent visit types (Table 17).

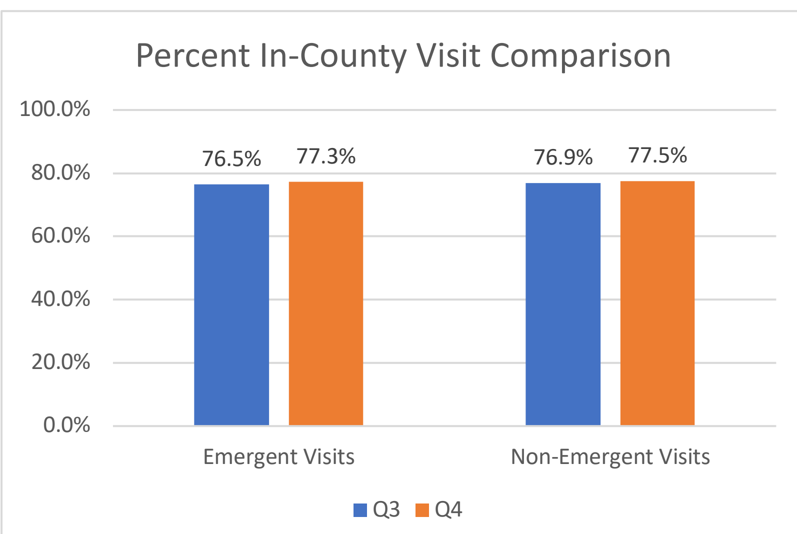

Figure 13: Percent Comparison of Emergent and Non-Emergent In-County ED Visits in Counties with Extended Power Outages between Q3 and Q4.

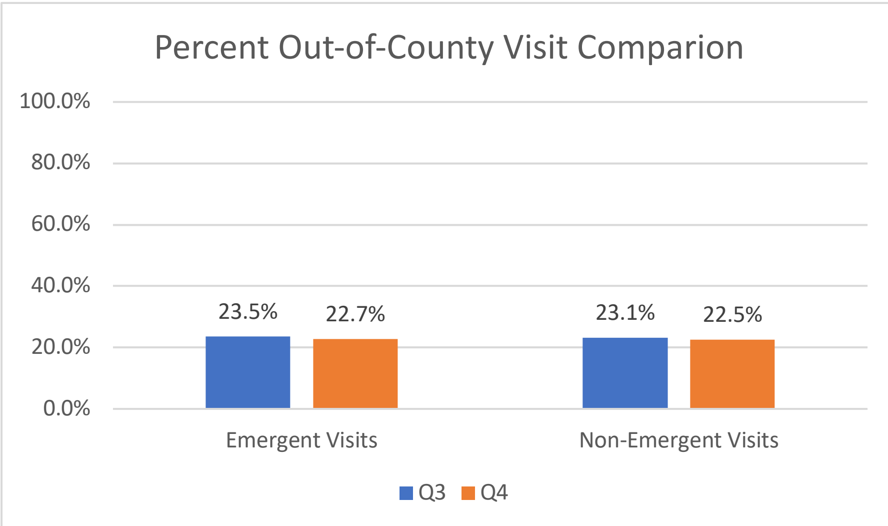

Figure 14: Percent Comparison of Emergent and Non-Emergent Out-of-County ED Visits in Counties with Extended Power Outages between Q3 and Q4.

Table 17: Frequency Comparison between In-and Out-of-County Differences from Q3 to Q4 within Emergent and Non-Emergent ED Visits in Counties with Extended Power Outages.

Visit Type and Location	Q3	Q4	% diff	p-value
Emergent in-county Visits (%)	815,832 (76.5)	866,635 (77.3)	0.8%	<.0001
Emergent out-of-county Visits (%)	250,265 (23.5)	254,491 (22.7)	-0.8%	
Non-Emergent in-county Visits (%)	233,736 (76.9)	247,368 (77.5)	0.6%	<.0001
Non-Emergent out-of-county Visits (%)	70,272 (23.1)	71,791 (22.5)	-0.6%	

Within in-county and non-emergent visits, there was a statistically significant difference in visits between Q3 and Q4 in counties with and without extended power outages (p <.0001). We saw an increase in the proportion of in-county ED visits from Q3 to Q4 for both extended power outage counties and non-power outage counties, with the former having a steeper increase (49.4% to 51.4%, 2% difference). We also saw an increase in the proportion of out-of-county ED visits from Q3 to Q4 for non-power outage counties (48.9% to 51.0%, 2.1% difference); the difference could potentially be due to the lower healthcare capacity and high demand in the rural counties across the panhandle where many local residents were affected by Hurricane Nate from the Gulf Coast in Q4. However, there appeared to be no statistically significant difference between Q3 and Q4 in out-of-county visits across counties with and without extended power outages (p=0.0719) (Table 18).

Table 18: Frequency Comparison of Non-Emergent ED Visits in Counties with and without Extended Power Outages.

Visit Type and Location	Q3	Q4	% diff	p-value
In-County - With Extended Power Outage (%)	233,736 (49.4)	247,368 (51.4)	2.0%	<.0001
In-County - No Extended Power Outage (%)	92,588 (49.4)	94,986 (50.6)	1.2%	
Out-of-County - With Extended Power Outage (%)	70,272 (49.5)	71,791 (50.5)	1.1%	0.0719
Out-of-County – No Extended Power Outage (%)	19,927 (48.9)	20,774 (51.0)	2.1%	

Research Question 3

How many and what types of care may be served using telehealth leading to potential cost savings?

To address how many potential non-emergent ED visits could be conducted using telehealth, we examined the total number of non-emergent in-and out-of-county billed visits across Florida during Q3 (Table 19). Based on available HCUP data, there was a total of 967,548 non-emergent ED charges across the state with 79.4% of them consisting of in-county visits. The categorization of non-emergent ED visits was based on ICD-10 codes and the NYU EDA methodology.

The expected payments of $505 for in-county and $545 for out-of-county visits were based on the CTPR estimates for each payer group previously described: Private Payers 40% of charges, Medicare and Other payers 25% of charges, and Medicaid 15% of charges. The expected payment for each ED visit was calculated as charges multiplied by CTPR, resulting in a payment estimate uniquely reflecting the resources used for each visit. Since cost data were not available for “potential virtual visits”, we used CPT codes for new patients for visits with similar severity as the codes used for the ED visits. Thus, the potential mean savings resulting from using telehealth for non-emergent ED visits amounted to $300 for in-county and $333 for out of county visits. With a total number of non-emergent in- and out-of-county ED charges adding up to 967,548 in Q3, the potential savings using telehealth could amount to over $296 million in one quarter alone (Table 19).

Table 19: ED Charges, Payments, and Potential Savings for Non-Emergent ED Visits across Florida in Q3 (N=967,548).

	Q3	
	In-County (n=768,383)	**Out-of-County (n=199,165)**
	Mean (SD)	Mean (SD)
Charge per ED Visit	$2,046 (2042.3)	$2,103 (2051.9)
Payment per ED Visit	$505 (616.7)	$545 (639.0)
Savings per ED Visit Using Telehealth	$300 (587.2)	$333 (610.6)
Total Potential Savings Using Telehealth	**$230,514,900**	**$66,321,945**

Overall, our analysis indicated a significant statistical difference in in- versus out-of-county emergent and non-emergent ED visits when controlling for pre- and post-hurricane indicators. The application of NYU EDA allowed us to clearly identify a portion of the non-emergent visits that could be addressed with telehealth. The savings that could be realized with potential use of telehealth added up to over $296 million during the quarter when Hurricane Irma made landfall in Florida.

CHAPTER V: DISCUSSION

Rolston and Meltzer (2015) note natural disasters in the U.S. have cost the country $110 billion in 2012 and $23 billion in 2013. Overall, the cost and frequency of billion-dollar events have increased from $127.8 billion in the 1980s to $456.7 billion between 2017-2019 (Smith & Mathews, 2020). The cost estimates are based on the best available numbers, but many believe that the actual cost is significantly higher than what is reported. It is difficult to get a real sense of the cost of the damages incurred as it spans over several years and may not be part of the publicly available information.

Healthcare costs are generally not accounted for in these estimates, continue past the initial event, and may increase over time. Many may change employers or become unemployed and dependent on Medicaid during and after natural disasters; hence it is challenging to measure the true healthcare costs for these events. One way to reduce the ongoing healthcare cost is to gain a better understanding of patients' behavior during natural disasters. To understand how, where, and with what variation patients seek care in the ED, this study focuses on analyzing the 2017 ED utilization data in Florida across three quarters when Hurricane Irma impacted Florida.

5.1 Discussion of Results

We conducted a retrospective descriptive quantitative analysis of ED visits using archival billing HCUP data. A comparison of the baseline pre-hurricane quarter (Q2) with subsequent quarters (Q3 and Q4) provided insights into changes in ED utilization patterns. The NYU EDA was utilized to classify the visits into distinct emergent versus non-emergent categories to evaluate which visits could potentially be treated remotely using telehealth.

Our analysis revealed that in counties under mandatory evacuations, there were no significant overall changes in the number and percent of in-county or emergent versus non-emergent visits for the residents. Within evacuation counties and among non-emergent visits, there is a statistically significant decrease in the proportion of visits from Q2 to Q3 within in-county visits, but an increase between this same time period in out-of-county-visits. This may be explained by the hurricane evacuation causing more individuals to seek care outside of their home county during and immediately following hurricane impact (Q3). Among non-emergent visits types, when comparing evacuation to non-evacuation counties, we saw a consistent decrease in the proportion of ED visits from Q2 to Q3 in both groups, regardless of in- or out-of-county location. However, there was a sharper decrease in evacuation counties when compared to non-evacuation counties (-2.8% versus -1.6%, and -1.7% versus -1.2%, for in and out-of-county respectively). This sharper decrease among evacuation counties may be related to patients' seeking less non-emergent care during and immediately after a natural disaster.

Within counties with extended power outages (>8 days), there appeared to be a statistically significant difference between in- and out-of-county visits with increases seen in the proportion of in-county visits over that time and a decrease among out-of-county visits both for emergent and non-emergent visit types. This may be indicative of individuals returning home to seek care in Q4, during the quarter after Irma made landfall. When comparing areas with and without extended power outages, there was a statistically significant increase in visits from Q3 and Q4 both within in- and out-of-county visits, with in-county visits having a sharper increase (2.0% versus 1.2%, $p<.0001$). However, there appeared to be no statistically significant difference between Q3 and Q4 in out-of-county visits across counties with and without extended power outages. This may also reflect the population who returned home to normalized life schedules.

Our analysis also revealed a larger proportion of in- versus out-of-county utilization of ED services for non-emergent visits in Q3 across Florida which was the quarter when Irma made landfall. On average, the mean charges and payments for non-emergent in-county ED visits were slightly lower than for out-of-county. With a total number of non-emergent in- and out-of-county ED charges adding up to 967,548 in Q3, the total potential savings using telehealth could amount to over $296 million in one quarter alone. If the ED utilization trends remain relatively consistent, as this analysis showed over three quarters, the savings for an entire year could add up to over $1B.

5.2 Recommendations

This study offers examples of natural disaster impact on patients seeking non-emergent care across different geographic service areas. Therefore, it is important to ensure easy access to and the necessary components for increased utilization of telehealth by displaced populations. The following are some recommendations for health systems, policy makers, local emergency services, private companies, and patients:

Infrastructure

Substantial investments in electrical grid and broadband infrastructure are needed that could withstand the majority of disasters (Der-Martirosian et al., 2020; Alverson et al., 2010). Frequent monitoring of power lines and allocation of redundancy plans or secondary power sources are critical components of a comprehensive readiness plan (Rolston & Meltzer, 2015). There is a need for robust wireless or mobile connection that would allow for telehealth interventions generally requiring more bandwidth (Grover et al., 2020; Uscher-Pines et al., 2018). The use of dedicated cellular networks has helped EMS personnel on the scene to connect with hubs for e-consultations. Access to secure networks should be prioritized as states and localities plan for a robust infrastructure (French et al., 2020). Disaster preparedness should also include redundancy in connectivity both at the state and health system levels (Doarn et al., 2018).

The use of Bluetooth technology for short-range needs has proven to be beneficial to connect computers and medical devices. More and more systems rely on wireless local networks to connect multiple devices at the same time. The use of 3G and 4G devices has increased the dependence on mobile broadband but cellular networks are often used heavily or are overwhelmed during natural disasters (Rolston & Meltzer, 2015).

Satellite services have provided the most reliable services after a disaster, however, the long range, high latency time has made video conferencing challenging (Rolston & Meltzer, 2015). The recent investments in 5G technology could have potentials to enable more adoption of smart devices with fast communication and personalized services. Unlike 2G, 3G, and 4G/LTE, 5G systems use fast, short-range signals on unused frequency bands for data transmission resulting in faster and more reliable connections and download speeds (Leong, 2019).

The shift to 5G technology will introduce better reliability with increased signal coverage and lower latency resulting from faster mobile speed. However, this new technology also requires a drastic increase in type and number of cellular networks, dual capability 4G/5G-enabled hardware, and advanced security and privacy practices to identify and bypass potential vulnerabilities. While most carriers are currently upgrading their systems to support 5G technology, the full extent of this investment will take several years (Leong, 2019). Collaboration between carriers, federal and local agencies, hospitals, and medical device companies could pave the way for a successful adoption of 5G technology that would benefit remote telehealth interventions during normal times or natural disasters. Until such goals are achieved, a combination of various technologies may help health systems and states to better prepare for natural disasters.

Technology

Network powered applications and approaches could be scalable and sustainable ways to providing care. Providers can reach many patients in a relatively brief time, and similarly, patients can have access to their PCPs or other doctors during a disaster (Price et al., 2015). Organized care agencies could use a web-based approach as part of the initial response to a disaster to conduct an initial assessment for non-critical cases. Examples of software technologies currently in use in Florida include VA VideoConnect, myPrivia, Vidyo, and others. Technology provides a convenient way for providers to access automated decision trees and reduce the burden of reporting for all healthcare workers. Portable modes can be especially helpful when communication lines are disrupted or overwhelmed at times (Wood et al., 2019).

Integrated systems among various entities especially with regional disaster response teams improves care outcomes even more. A system-based approach to screening, diagnosing, and treating patients can yield better outcomes (Andrews & Quintana, 2015; Wood et al., 2019). Assignment of internal and external champions throughout the development and implementation of new technologies will ensure more synergy and engagement across the enterprise (Kim et al., 2013). Deployment of new modalities requires buy-in and participation from stakeholders across operations, marketing, clinical, legal, and other lines of business. Ongoing maintenance and support require personnel capacity dedicated and well-versed in technology and constant evaluation of practices (Elliott & Yopes, 2019; Kim et al., 2013).

Technology provides an opportunity to manage the surge of patients in EDs and shelters and offers a streamlined way to triage with the help of e-consultations (Wood et al., 2019). Use of technology can also alleviate some of the load on ICU and ED providers who require rest between long shifts by ensuring RPM for those critically ill. During subacute and chronic recovery phases, technology can also be an efficient way to provide RPM with oversight of primary physicians or assigned nurses (Rolston & Meltzer, 2015).

The arrival and surge in use of smartphones and networks are rapidly reducing the costs associated with data acquisition and data transfer. mHealth on patients' personal smart devices can allow for remote consultation and direct linkage to providers during critical times. Smart devices are offering new ways to expedite the time for surveillance, detection, and monitoring of emerging conditions. The required infrastructure, however, needs to support large amounts of data transfer and analysis. Capabilities for self-testing at home will be the next phase of putting more power into patients' hands instead of relying on staff availability. The combination of robust infrastructures, wider use of smart devices, and more affordable data plans could have a significant impact on telehealth adoption (Wood et al., 2019).

Use of the Android platform is more common in some ethnic groups; some groups can also benefit from embedded translation services in the platforms. Effective use of digital technology to deliver health requires a good understanding of users' psychosocial and behavioral needs and creative ways to keep them engaged. Incorporation of social behavioral principles in product design, such as mirroring or aesthetic usability effect, could offer immense benefits for more comprehensive data collection and analysis (Chan et al., 2017).

Lastly, usability of technology is directly linked to its design. An understanding of the application structure, age- and ethnicity-related considerations, user interface best practices, ease of use, and involvement of users in testing and evaluation could be critical factors. Design thinking has become more advanced and popular in understanding user groups' preferences. Many providers and patients are also concerned with privacy and security of online applications; such concerns must be addressed consistently during user testing or end-user training (Yuen et al., 2016).

Planning and Resource Allocation

For health systems, planning can start with appropriate measures to assess and avoid risks. The design and construction of buildings may be a critical factor when experiencing ED surge or when housing displaced residents temporarily during natural disasters. Preparations for disaster response with frequent and mandatory training for staff, resource acquisition and allocation, and appropriate communication systems are critical (Crutchfield & Harkey, 2019; Rolston & Meltzer, 2015).

Availability of ventilators, oxygen, dialysis devices, and monitors are essential. Similarly, collaboration, coordination, and integration with the local incident command center provides better real-time readiness for a health system (Rolston & Meltzer, 2015). Dedicated hotlines that are staffed with trained individuals, proactively coordinated with EMS and local agencies, and advertised in communities can also assist with surging call volumes during and after a natural disaster (Crutchfield & Harkey, 2019).

Effective expansion of telehealth use requires health systems' preparation for better staff training in chief complaints, advance arrangement of appropriate equipment, efficient resource allocation in ICUs, availability of operating rooms, ICU beds and trauma surgeons (Crutchfield & Harkey, 2019). The guidelines issued by the American College of Chest Physicians recommends equipment, personnel and facility availability for at least ten days following a disaster (Rolston & Meltzer, 2015).

As noted earlier, the use of technology can provide critical decision making in a rapid and cost-effective way through reducing the use of EMS, shortening ambulance diversions, lowering wait times, and eliminating non-urgent use of ED (Winburn et al., 2017). Appropriate pre-hospital triage protocols can decrease the burden of local emergency personnel and hospital-based providers. Patient triage during natural disasters should ensure only those with most emergent needs are transferred to EDs. A more balanced distribution of patients will shorten wait time and rapid stabilization upon arrival in EDs (Rolston & Meltzer, 2015).

An increase in capacity may include options used frequently by the military such as mobile earth-bound and temporary portable facilities with different configurations. These types of foldable and collapsible facilities can be quickly assembled at a disaster site by the national guard who are typically deployed to disaster zones. Such facilities could be staffed with knowledgeable clinicians who can care for critically ill on the scene and eliminate unnecessary ED transports from remote areas (Bitterman & Zimmer, 2018).

Provider and Patient Behavior

Physicians and nurses are, at times, hesitant to use technology partially due to concerns about responsibility for sensitive data, lack of in-house integration, or simply feeling ill-prepared and overwhelmed. Investments in quick and easy training to implement and use technology and define alternate triage flow in regular settings, EDs, or shelters could eliminate some of the discomfort (Grover et al., 2020). When systems are fully integrated and staff is trained, the learning curve won't be as steep during natural disasters (Der-Martisorian et al., 2019; Doarn et al., 2018). The use of systems during routine care delivery will increase preparedness (Lurie & Carr, 2018; Ohta et al., 2017). Use of technology and triage algorithms in training will also be an effective way for knowledge transfer when establishing triage protocols for staff during natural disasters (Rolston & Meltzer, 2015).

Increased training to improve providers' understanding of technology and its benefits must start earlier during their studies and continue into their practice (Kim et al., 2013). Regular use of electronic devices such as e-stethoscopes and cameras will encourage physicians and nurses to explore new tools. But, in addition to their comfort level with technology, providers must also believe that the quality of care using telehealth can yield the same results as in-person visits (Ohta et al., 2017).

The high levels of diagnostic agreements between virtual and face-to-face outpatient diagnosis explored by Ohta et al. (2017) in Japan have to become a part of quality measurements in healthcare settings. Use of web-based or application specific surveillance mapping, screening, triage, diagnosis, and remote monitoring must become part of how healthcare workers provide care. While the implementation and lack of homogenous interventions may pose a challenge, the use of technology can facilitate the necessary conversations to address the areas of concern among providers (Alwashmi, 2020).

The gap for internet and smartphone use is closing between urban, suburban, and rural areas. The prevalence of smartphone usage combined with more services being offered through various applications make technology more accessible (Bunnell et al., 2017). However, patients may still be hesitant to use technology due to privacy and security issues or if they feel stigmatized for using a visible device. Similar to providers, patients also need to feel comfortable about the parity in quality of care they receive virtually versus in-person (Ohta et al., 2017).

Many rural residents don't have easy access to providers or have limited transportation opportunities. These individuals could benefit from telehealth use and better broadband infrastructure in their areas for appointments and follow-up monitoring. Patients' uninterrupted access to broadband and smart devices will be a determining factor for technology adoption (Wood et al., 2019). Older generations may be less receptive to learn complex interfaces but there is evidence that the flexibility for elderly or their caregivers to access providers remotely has been well received over the years (Elliott & Yopes, 2019).

Many patients especially those exposed to technology at work or in their personal lives are more willing to try new direct-to-consumer (DTC) or self-pay care that are becoming more popular in the market. The changing behavior is partially due to consumerization of IT, convenience, and comfort level with technology. Reasonably priced DTC care can be appealing for cost-conscious individuals who may opt for a point solution versus committing to a high-deductible insurance plan (Elliott & Yopes, 2019).

Collaboration

Nearly 250 million 911 calls are received by approximately 20,000 EMS agencies in the US every year. The overuse of EMS services by primary care patients in the U.S. is as high as 56% and it tends to be higher during catastrophic events (Langabeer II, et al., 2017). The use of telehealth during natural disasters can serve as real-time mentoring and training for first responders who may have inadequate medical training. The use of technology before and during a natural disaster allows for better visualizations of patients with severe illnesses and facilitates real-time communications between the hub and the surrogate care providers on-site. In addition to engagements with local hospitals, EMS collaboration with primary care physicians (PCPs) during e-consultations who know patients and understand local needs best can be beneficial (Augusterfer et al., 2018).

Collaborations among state and local agencies, EMS, and hospitals can produce robust telehealth models to provide optimal care in emergency shelters, EDs, and patients at home. The support of public health responders in shelters can assist with necessary immunizations, infectious disease surveillance and outbreaks as well as assessment of environmental exposures (Turner et al., 2019). Technology can facilitate multi-way conversations for consultation on severe cases; these collaborations expedite the decision-making process and increase the confidence of those on the frontlines (Rolston & Meltzer, 2015). Equipping stakeholders with appropriate tools configured for immediate use can expedite delivery of care during a disaster (French et al., 2020).

Policy

Several studies have noted that extension of medical care beyond state or even country borders has become more complex due to existing policies that continue to remain in flux. Clear policies for licensure, credentialing, malpractice, privacy, security, and distinction of service type are needed (Doarn et al., 2018; Kim et al., 2013). Coordination and collaboration with various subject matter experts instead of reliance on large employers or Political Action Committees (PACs) before policy development can make a significant difference. Agreement on the future state of healthcare can drive many decisions including investment areas and policy changes such as decisions on EHR integrations and multimedia capabilities (Doarn et al., 2018; Kim et al., 2013).

With many uninsured and underinsured populations living in rural areas and an increase in comorbidities across the nation, health policy design should be in support of broadening access to and facilitating better care of complex medical conditions. Efforts to drive more technology adoption and integration may be better supported by eliminating mandates for strict patient-doctor relationships. Removal of such restrictions will allow for more and better access to specialized care around the country while keeping PCPs informed (Carr, 2020). Provision of guidance and best practices on documentation, processes, technology requirements, coordination of policies and procedures, and sample manuals would help many healthcare systems put the necessary steps in place for a more integrated and comprehensive approach to care delivery with the support of appropriate policies (Uscher-Pines et al., 2018).

Temporary state regulatory changes to allow for out-of-state physicians to provide care during a hurricane has become a common practice favored by many local leaders. While this approach may offer a short-term fix, it doesn't present a sustainable model of care. State-led and controlled programs such as Medicaid continue to have varying eligibility criteria during normal times and throughout natural disasters resulting in lack of clarity for many beneficiaries (Khairat et al., 2020; Guclu et al., 2016). Similarly, multistate licensure should not pose a barrier to telehealth adoption (Uscher-Pines et al., 2018).

Policymakers should encourage and support lower prices for telehealth visits. Until such a time, there should be considerations for payment parity for telehealth and in-person visits across all states. As seen in states such as South Carolina, health systems and insurance providers should wave payments for telehealth visits for a specific period during and after a catastrophic event regardless of insurance status (Guclu et al., 2016). Reimbursements for in-person or virtual care visits between a provider and evacuees without a prior relationship should be encouraged and become a standard practice (Khairat et al., 2020; Guclu et al., 2016). States should also consider legislation that allows patients to obtain emergency refills during declared states of emergency without a new prescription to avoid medication errors, exacerbation of existing conditions, or even death. Adoption of standardized technology and integration of systems could reduce the opportunity for fraud. (Grover et al., 2020).

Federal and local government must clarify the delineation of roles between public and private sectors more clearly. Encouraging and supporting public-private partnerships with appropriate level of oversight, will allow for more innovation but it also ensures minimum checks and balances can be considered and implemented. Clarification of roles will offer more financing options for telehealth adoption and will shed light on potential areas for liability (Uscher-Pines et al., 2016). Private and public partnerships will also encourage more PCPs and clinicians to utilize technology; however, investments in telehealth require funding for engagement, implementation and maintenance of technology before a disaster occurs. Flexibility with available federal- and state-level funding for equipment, software, and personnel could facilitate better disaster preparedness. Despite recent reliance on telehealth during the COVID-19 era, the investments and robustness of such capabilities continue to vary across various states (Pamplin et al., 2019; Kim et al., 2013; Guclu et al, 2016).

Lastly, the current EMS protocols for most agencies require patient transfer to the ED versus other appropriate settings for non-urgent complaints to ensure accurate reimbursement as required by Medicare (Langabeer II et al., 2016; Langabeer II et al., 2017). Many suggest that the telehealth application has offered an untapped opportunity to expand the existing community paramedic models for disaster response and routine home visits to include broader reach and more responsibilities (French et al., 2020). Reimagining the current model means that telehealth becomes a way to provide care versus an add on. To accomplish such change, the new model must incentivize EMS for transports to appropriate non-urgent settings that could increase resource utilization and patient satisfaction by reducing unnecessary ED visits and wait times (Der-Martirosian et al., 2020; Langabeer II et al., 2016).

The CMS innovation (CMMI) announced a new voluntary 5-year payment model for EMS agencies referred to as Emergency Triage, Treat and Transport (ET3). The model allows EMS agencies to be reimbursed for handling of 911 calls by decoupling EMS assessment and ED treatment. This initiative could save up to $560 million annually in ED expenditures if approximately 15% of the Medicare ambulance transports could be handled outside of an ED (Munjal et al., 2019). The ET3 model aligns EMS agencies to pursue new communication technologies, decision-support applications, and point of care laboratory testing for better patient-centered care resulting in new collaborations between EMS and various community resources (Munjal et al., 2019).

Innovative efforts such as the one introduced by CMMI to rethink emergency response can be an effective tool for policymakers to support the quadruple aim. Policies in support of expansion of ET3 model for better training of local EMS and expansion of their responsibilities coupled with appropriate payment models have the potential to address many challenges. EMS personnel would be able to provide care on the scene through e-consultation or safely transfer patients to appropriate settings. Similarly, policies in support of better accuracy and tracking of patient safety thorough electronic health information data transmission between EMS and community health systems could result in better quality outcomes (Munjal et al., 2019).

5.3 Limitations

Several limitations were identified for this study. The analysis assumes accuracy of the secondary HCUP data obtained through AHRQ. This study focuses on one state and one natural disaster event (Hurricane Irma) and the results may not be generalizable outside of this example. The limitations in HCUP data format resulted in the analysis design that compares quarters versus exact times for Hurricane Irma making landfall, and when mandatory evacuations and extended power outages occurred. Evaluation of three quarters may also present a short time span that affect the overall generalizability of the study.

This study only focuses on ED admissions and discharges and didn't capture patients' needs after transfer or discharge. The potential savings presented in this study doesn't account for cost of transportation, infrastructure investments, or variations in labor utilization.

Lastly, this study does not examine mortality rate or long-term cost of care due to exacerbation of chronic conditions. In this descriptive analysis providers' and patients' attitudes toward technology or their socioeconomic characteristics were not considered. Similarly, the study did not capture hospitals' characteristics, their preparedness, level of staffing, or type of system utilized for telehealth or in-person interventions.

5.4 Future Studies

There is a need for similar studies analyzing evacuees' behaviors during natural disasters across various states as a way to compare trends and medical needs. Future studies should assess and understand the real-time distribution of intensivists across the US and optimal staffing ratios during natural disasters including specialists, surgeons, ER physicians, and nurses. There is also a gap in comprehensive studies about available shelters, their readiness plans, and ratio and skills of healthcare workers on-site. Shelters may be a location where future non-emergent telehealth initiatives may be of help.

Further, more studies need to focus on comparisons of centralized and decentralized remote services model in the short- and long-term for various diagnoses, interventions, and monitoring needs. Long-term needs and cost of care for exacerbated chronic conditions that remain unattended during a natural disaster need to be closely assessed to evaluate the actual cost to health systems and patients. In addition, many providers and patients remain hesitant to using telehealth services as a primary avenue for access to care due to beliefs that the quality may not be as good as in-person visits. More extensive research is needed to compare the quality of care for diagnosis and interventions followed with education of both providers and patients.

As organizations vary in their infrastructure and standards, a comparison of response and quality of care could be beneficial in understanding best practices for recovery, transfer, or discharge. Further, quantifying care delivery and disruptions during, before and after a storm as part of a longitudinal study could improve the efficacy of interventions. Similarly, a comparison of quality of care with onsite staff versus temporary supplemental teams from outside the community could provide many valuable insights.

As power outages and connectivity disruptions present a significant barrier to telehealth adoption, there is a need for studies that examine telecommunications service disruption patterns and the sustainability of generators to provide remote care services. Future studies should closely examine the long-term health tolls and cost of care for vulnerable populations and rural areas in hurricane-prone areas. Lastly, more studies are needed to understand provider- and patient-centered design and adoption of various telehealth technologies.

5.5 Conclusion

Natural Disasters including hurricanes and pandemics pose unique set of challenges for providers and patients. Regular care delivery is often disrupted due to environmental factors. Application of telehealth will have its own challenges but it can also be well suited for situations when telecommunication and power infrastructures remain intact. Appropriate planning, early investments, a fully functioning infrastructure, and availability of clinicians are critical during any natural disaster. Similarly, reimbursement guidelines, licensing and credentialing across hospitals and state lines must support adoption and use of telehealth across large healthcare systems and smaller health centers.

Telehealth has been more broadly adopted in Europe where the per capita cost of care is lower and patient experience is better. While the recurrence of catastrophic events has not been as prominent in Europe as in the U.S., the investments in infrastructure, technology, and training would benefit them during unexpected events. The surge of telehealth use during severe hurricanes and the COVID-19 pandemic has been supported with short-term availability of federal budget and temporary state regulatory changes in the U.S. For telehealth use to become a primary avenue of care delivery, policymakers at federal and local levels must strongly commit to supporting the various modalities across the nation for all demographics. Several modifications introduced by CMS during the COVID-19 pandemic to waive telehealth restrictions to avoid overburdening the health systems should become standard practice.

List of Tables

Table 1: Keywords for Literature Review.

	Telehealth	**Natural Disasters**	**Medica Terms**
MeSH Terms	Telehealth Telemedicine eHealth mHealth e-visit web-based intervention mobile health intervention online intervention teleconsultation direct-to-consumer visit virtual urgent care virtual visit video visit remote visit synchronous communication asynchronous communication remote patient monitoring	Natural Disaster Hurricanes Flooding Wildfires Earthquake Catastrophic events Typhoons Tropic cyclones Tsunami Severe storms Tornado	DHA Doctor of Health Administration

Table 2: Florida counties that faced mandatory evacuations during Hurricane Irma.

Brevard	Flagler	Martin	Pinellas
Broward	Glades	Miami-Dade	Sarasota
Citrus	Hendry	Monroe	Seminole
Collier	Hernando	Orange	St. Lucie
Dixie	Indian River	Palm Beach	Sumter
Duval	Lee	Pasco	Volusia

Table 3: Florida counties, 2017 Population, and Zip Codes.

County	2017 Population	Zip Codes
Alachua	266,309	32601, 32602, 32603, 32604, 32605, 32606, 32607, 32608, 32609, 32610, 32611, 32612, 32613,32614, 32615, 32616, 32618, 32627, 32631, 32633, 32635, 32640, 32641, 32643, 32653, 32654, 32655, 32658, 32662, 32667, 32669, 32694

Baker	28,254	32040, 32063, 37072, 32087
Bay	184,736	32401, 32402, 32403, 32404, 32405, 32406, 32407, 32408, 32409, 32410, 32411, 32412, 32413, 32417, 32438, 32444, 32466
Bradford	27,142	32042, 32044, 32058, 32091, 32622
Brevard	587,769	32754, 32775, 32780, 32781, 32782, 32783, 32796, 32815, 32899, 32901, 32902, 32903, 32904, 32905, 32906, 32907, 32908, 32909, 32910, 32911, 32912, 32919, 32920, 32922, 32923, 32924, 32925, 32926, 32927, 32931, 32932, 32934, 32935, 32936, 32937, 32940, 32949, 32950, 32951, 32952, 32953, 32954, 32955, 32956, 32959, 32976
Broward	1,934,516	33004, 33008, 33009, 33019, 33020, 33021, 33022, 33023, 33024, 33025, 33026, 33027, 33028, 33029, 33060, 33061, 33062, 33063, 33064, 33065, 33066, 33067, 33068, 33069, 33071, 33072, 33073, 33074, 33075, 33076, 33077, 33081, 33082, 33083, 33084, 33093, 33097, 33301, 33302, 33303, 33304, 33305, 33306, 33307, 33308, 33309, 33310, 33311, 33312, 33313, 33314, 33315, 33316, 33317, 33318, 33319, 33320, 33321, 33322, 33323, 33324, 33325, 33326, 33327, 33328, 33329, 33330, 33331, 33332, 33334, 33335, 33336, 33337, 33338, 33339, 33340, 33345, 33346, 33348, 33349, 33351, 33355, 33359, 33388, 33394, 33441, 33442, 33443
Calhoun	14,428	32421, 32424, 32430, 32449
Charlotte	181,522	33927, 33938, 33946, 33947, 33948, 33949, 33950, 33951, 33952, 33953, 33954, 33955, 33980, 33981, 33982, 33983, 34224
Citrus	145,415	34423, 34428, 34429, 34433, 34434, 34436, 34442, 34445, 34446, 34447, 34448, 34450, 34451, 34452, 34453, 34460, 34461, 34464, 34465, 34487
Clay	212,228	32003, 32006, 32030, 32043, 32050, 32065, 32067, 32068, 32073, 32079, 32160, 32656
Collier	372,678	34101, 34102, 34103, 34104, 34105, 34106, 34107, 34108, 34109, 34110, 34112, 34113, 34114, 34116, 34117, 34119, 34120, 34137, 34138, 34139, 34140, 34142, 34143, 34145, 34146
Columbia	69,999	32024, 32025, 32038, 32055, 32056, 32061
DeSoto	37,241	34265, 34266, 34267, 34268, 34269
Dixie	16,615	32628, 32648, 32680, 32692
Duval	937,933	32099, 32201, 32202, 32203, 32204, 32205, 32206, 32207, 32208, 32209, 32210, 32211, 32212, 32214, 32215, 32216, 32217, 32218, 32219, 32220, 32221, 32222, 32223, 32224, 32225, 32226, 32227, 32228, 32229, 32230, 32231, 32232, 32233, 32234, 32235, 32236, 32237, 32238, 32239, 32240, 32241, 32244, 32245, 32246, 32247, 32250, 32254, 32255, 32256, 32257, 32258, 32266, 32267, 32277, 32290
Escambia	313,249	32501, 32502, 32503, 32504, 32505, 32506, 32507, 32508, 32509, 32511, 32512, 32513, 32514, 32516, 32520, 32521, 32522, 32523, 32524, 32526, 32533, 32534, 32535, 32559, 32560, 32568, 32577, 32590, 32591, 32592
Flagler	109,999	32110, 32135, 32136, 32137, 32142, 32164
Franklin	11,724	32320, 32322, 32323, 32328, 32329
Gadsden	45,993	32324, 32330, 32332, 32333, 32343, 32351, 32352, 32353
Gilchrist	17,900	32619, 32693
Glades	13,580	33471, 33944

Gulf	16,105	32456, 32457, 32465
Hamilton	14,364	32052, 32053, 32096
Hardee	27,154	33834, 33865, 33873, 33890
Hendry	41,018	33440, 33930, 33935, 33975
Hernando	186,704	34601, 34602, 34603, 34604, 34605, 34606, 34607, 34608, 34609, 34611, 34613, 34614, 34636, 34661
Highlands	103,852	33825, 33826, 33852, 33857, 33862, 33870, 33871, 33872, 33875, 33876, 33960
Hillsborough	1,426,736	33503, 33508, 33509, 33510, 33511, 33527, 33530, 33534, 33547, 33548, 33549, 33550, 33556, 33558, 33559, 33563, 33564, 33565, 33566, 33567, 33568, 33569, 33570, 33571, 33572, 33573, 33575, 33583, 33584, 33586, 33587, 33592, 33594, 33595, 33598, 33601, 33602, 33603, 33604, 33605, 33606, 33607, 33608, 33609, 33610, 33611, 33612, 33613, 33614, 33615, 33616, 33617, 33618, 33619, 33620, 33621, 33622, 33623, 33624, 33625, 33626, 33629, 33630, 33631, 33633, 33634, 33635, 33637, 33647, 33650, 33651, 33655, 33660, 33661, 33662, 33663, 33664, 33672, 33673, 33674, 33675, 33677, 33679, 33680, 33681, 33682, 33684, 33685, 33686, 33687, 33688, 33689, 33690, 33694, 33697
Holmes	19,427	32425, 32452, 32464
Indian River	154,241	32948, 32957, 32958, 32960, 32961, 32962, 32963, 32964, 32965, 32966, 32967, 32968, 32969, 32970, 32971, 32978
Jackson	48,289	32420, 32423, 32426, 32431, 32432, 32440, 32442, 32443, 32445, 32446, 32447, 32448, 32460
Jefferson	14,165	32336, 32337, 32344, 32345, 32361
Lafayette	8,602	32013, 32066
Lake	345,432	32102, 32158, 32159, 32702, 32726, 32727, 32735, 32736, 32756, 32757, 32767, 32776, 32778, 32784, 34705, 34711, 34712, 34713, 34714, 34715, 34729, 34731, 34736, 34737, 34748, 34749, 34753, 34755, 34756, 34762, 34788, 34789, 34797
Lee	740,000	33901, 33902, 33903, 33904, 33905, 33906, 33907, 33908, 33909, 33910, 33911, 33912, 33913, 33914, 33915, 33916, 33917, 33918, 33919, 33920, 33921, 33922, 33924, 33928, 33931, 33932, 33936, 33945, 33956, 33957, 33965, 33966, 33967, 33970, 33971, 33972, 33990, 33991, 33993, 33994, 34133, 34134, 34135, 34136
Leon	290,965	32301, 32302, 32303, 32304, 32305, 32306, 32307, 32308, 32309, 32310, 32311, 32312, 32313, 32314, 32315, 32316, 32317, 32318, 32362, 32395, 32399
Levy	40,276	32621, 32625, 32626, 32639, 32644, 32668, 32683, 32696, 34446, 34498
Liberty	8,236	32321, 32334, 32335, 32360
Madison	18,474	32059, 32331, 32340, 32341, 32350
Manatee	385,506	34201, 34202, 34203, 34204, 34205, 34206, 34207, 34208, 34209, 34210, 34211, 34212, 34215, 34216, 34217, 34218, 34219, 34220, 34221, 34222, 34228, 34243, 34250, 34251, 34260, 34264, 34270, 34280, 34281, 34282
Marion	353,339	32111, 32113, 32133, 32134, 32179, 32182, 32183, 32192, 32195, 32617, 32634, 32663, 32664, 32681, 32686, 34420, 34421, 34430, 34431, 34432, 34470, 34471, 34472, 34473, 34474, 34475, 34476,

		34477, 34478, 34479, 34480, 34481, 34482, 34483, 34488, 34489, 34491, 34492
Martin	159,701	33455, 33475, 34956, 34957, 34958, 34990, 34991, 34992, 34994, 34995, 34996, 34997
Miami-Dade	2,713,295	33002, 33010, 33011, 33012, 33013, 33014, 33015, 33016, 33017, 33018, 33030, 33031, 33032, 33033, 33034, 33035, 33039, 33054, 33055, 33056, 33090, 33092, 33101, 33102, 33107, 33109, 33110, 33111, 33112, 33114, 33116, 33119, 33121, 33122, 33124, 33125, 33126, 33127, 33128, 33129, 33130, 33131, 33132, 33133, 33134, 33135, 33136, 33137, 33138, 33139, 33140, 33141, 33142, 33143, 33144, 33145, 33146, 33147, 33148, 33149, 33150, 33151, 33152, 33153, 33154, 33155, 33156, 33157, 33158, 33159, 33160, 33161, 33162, 33163, 33164, 33165, 33166, 33167, 33168, 33169, 33170, 33172, 33173, 33174, 33175, 33176, 33177, 33178, 33179, 33180, 33181, 33182, 33183, 33184, 33185, 33186, 33187, 33188, 33189, 33190, 33193, 33194, 33195, 33196, 33197, 33199, 33231, 33233, 33234, 33238, 33239, 33242, 33243, 33245, 33247, 33255, 33256, 33257, 33261, 33265, 33266, 33269, 33280, 33283, 33296, 33299, 34141
Monroe	76,483	33001, 33036, 33037, 33040, 33041, 33042, 33043, 33045, 33050, 33051, 33052, 33070
Nassau	82,925	32009, 32011, 32034, 32035, 32041, 32046, 32097
Okaloosa	203,478	32531, 32536, 32537, 32539, 32540, 32541, 32542, 32544, 32547, 32548, 32549, 32564, 32567, 32569, 32578, 32579, 32580, 32588
Okeechobee	41,275	34972, 34973, 34974
Orange	1,355,921	32703, 32704, 32709, 32710, 32712, 32751, 32768, 32777, 32789, 32790, 32792, 32793, 32794, 32798, 32801, 32802, 32803, 32804, 32805, 32806, 32807, 32808, 32809, 32810, 32811, 32812, 32814, 32816, 32817, 32818, 32819, 32820, 32821, 32822, 32824, 32825, 32826, 32827, 32828, 32829, 32830, 32831, 32832, 32833, 32834, 32835, 32836, 32837, 32839, 32853,32854, 32855, 32856, 32857, 32858, 32859, 32860, 32861, 32862, 32867, 32868, 32869, 32872, 32877, 32878, 32885, 32886, 32887, 32890, 32891, 32893, 32896, 32897, 32898, 34734, 34740, 34760, 34761, 34777, 34778, 34786, 34787
Osceola	353,623	33848, 34739, 34741, 34742, 34743, 34744, 34745, 34746, 34747, 34758, 34769, 34770, 34771, 34772, 34773
Palm Beach	1,470,344	33401, 33402, 33403, 33404, 33405, 33406, 33407, 33408, 33409, 33410, 33411, 33412, 33413, 33414, 33415, 33416, 33417, 33418, 33419, 33420, 33421, 33422, 33424, 33425, 33426, 33427, 33428, 33429, 33430, 33431, 33432, 33433, 33434, 33435, 33436, 33437, 33438, 33439, 33444, 33445, 33446, 33447, 33448, 33454, 33458, 33459, 33460, 33461, 33462, 33463, 33464, 33465, 33466, 33467, 33468, 33469, 33470, 33474, 33476,33477, 33478, 33480, 33481, 33482, 33483, 33484, 33486, 33487, 33488, 33493, 33496, 33497, 33498, 33499
Pasco	525,141	33523, 33524, 33525, 33526, 33537, 33539, 33540, 33541, 33542, 33543, 33544, 33574, 33576, 33593, 34610, 34637, 34638, 34639, 34652, 34653, 34654, 34655, 34656, 34667, 34668, 34669, 34673, 34674, 34679, 34680, 34690, 34691, 34692

Pinellas	968,341	33701, 33702, 33703, 33704, 33705, 33706, 33707, 33708, 33709, 33710, 33711, 33712, 33713, 33714, 33715, 33716, 33729, 33730, 33731, 33732, 33733, 33734, 33736, 33737, 33738, 33740, 33741, 33742, 33743, 33744, 33747, 33755, 33756, 33757, 33758, 33759, 33760, 33761, 33762, 33763, 33764, 33765, 33766, 33767, 33769, 33770, 33771, 33772, 33773, 33774, 33775, 33776, 33777, 33778, 33779, 33780, 33781, 33782, 33784, 33785, 33786, 34660, 34677, 34681, 34682, 34683, 34684, 34685, 34688, 34689, 34695, 34697, 34698
Polk	685,368	33801, 33802, 33803, 33804, 33805, 33806, 33807, 33809, 33810, 33811, 33812, 33813, 33815, 33820, 33823, 33827, 33830, 33831, 33835, 33836, 33837, 33838, 33839, 33840, 33841, 33843, 33844, 33845, 33846, 33847, 33849, 33850, 33851, 33853, 33854, 33855, 33856, 33858, 33859, 33860, 33863, 33867, 33868, 33877, 33880, 33881, 33882, 33883, 33884, 33885, 33888, 33896, 33897, 33898, 34759
Putnam	73,384	32007, 32112, 32131, 32138, 32139, 32140, 32147, 32148, 32149, 32157, 32177, 32178, 32181, 32185, 32187, 32189, 32193, 32666
St. Johns	243,693	32004, 32033, 32080, 32081, 32082, 32084, 32085, 32086, 32092, 32095, 32145, 32259, 32260
St. Lucie	313,163	34945, 34946, 34947, 34948, 34949, 34950, 34951, 34952, 34953, 34954, 34979, 34981, 34982, 34983, 34984, 34985, 34986, 34987, 34988
Santa Rosa	174,049	32530, 32561, 32562, 32563, 32565, 32566, 32570, 32571, 32572, 32583
Sarasota	419,680	34223, 34229, 34230, 34231, 34232, 34233, 34234, 34235, 34236, 34237, 34238, 34239, 34240, 34241, 34242, 34272, 34274, 34275, 34276, 34277, 34278, 34284, 34285, 34286, 34287, 34288, 34289, 34292, 34293, 34295
Seminole	462,801	32701, 32707, 32708, 32714, 32715, 32716, 32718, 32719, 32730, 32732, 32733, 32745, 32746, 32747, 32750, 32752, 32762, 32765, 32766, 32771, 32772, 32773, 32779, 32791, 32795, 32799
Sumter	124,995	32162, 33513, 33514, 33521, 33538, 33585, 33597, 34484, 34785
Suwannee	44,124	32008, 32060, 32062, 32064, 32071, 32094
Taylor	21,781	32347, 32348, 32356, 32357, 32359
Union	15,448	32026, 32054, 32083, 32697
Volusia	537,868	32105, 32114, 32115, 32116, 32117, 32118, 32119, 32120, 32121, 32122, 32123, 32124, 32125, 32126, 32127, 32128, 32129, 32130, 32132, 32141, 32168, 32169, 32170, 32173, 32174, 32175, 32176, 32180, 32190, 32198, 32706, 32713, 32720, 32721, 32722, 32723, 32724, 32725, 32728, 32738, 32739, 32744, 32753, 32759, 32763, 32764, 32774
Wakulla	32,050	32326, 32327, 32346, 32355, 32358
Walton	68,021	32422, 32433, 32434, 32435, 32439, 32454, 32455, 32459, 32461, 32538, 32550
Washington	24,546	32427, 32428, 32437, 32462, 32463

Table 4: Power Outages by County During and After Hurricane Irma.

County	% Power Outage at Peak	Duration of Power Restoration		County	% Power Outage at Peak	Duration of Power Restoration
Alachua	53%	September 10-18		Lee	82%	September 10-21
Baker	94%	September 11-18		Leon	42%	September 10-13
Bay	3%	September 9, 11-13		Levy	73%	September 9, 10-17
Bradford	95%	September 11-18		Liberty	81%	September 11-12
Brevard	86%	September 10-17		Madison	67%	September 9, 11-17
Broward	76%	September 9-17		Manatee	63%	September 10-18
Calhoun	26%	September 9, 11-12		Marion	76%	September 10-18
Charlotte	64%	September 10-19		Martin	82%	September 10-16
Citrus	79%	September 10-18		Miami-Dade	81%	September 9-19
Clay	88%	September 10-16		Monroe	85%	September 9-27
Collier	96%	September 10-22		Nassau	98%	September 10-19
Columbia	92%	September 10-17		Okaloosa	0%	N/A
DeSoto	89%	September 10-19		Okeechobee	96%	September 10-17
Dixie	75%	September 10-17		Orange	62%	September 10-19
Duval	85%	September 11-16		Osceola	43%	September 10-18
Escambia	1%	September 11-12		Palm Beach	74%	September 10-17
Flagler	91%	September 10-17		Pasco	71%	September 10-16
Franklin	58%	September 9, 11-14		Pinellas	79%	September 10-17
Gadsden	67%	September 11-13		Polk	66%	September 10-19
Gilchrist	79%	September 9, 10-17		Putnam	89%	September 10-18
Glades	67%	September 10-21		St. Johns	100%	September 10-18
Gulf	41%	September 11-14		St. Lucie	74%	September 10-16
Hamilton	78%	September 11-17		Santa Rosa	0%	N/A
Hardee	97%	September 10-19		Sarasota	66%	September 10-19
Hendry	100%	September 10-24		Seminole	93%	September 10-19
Hernando	62%	September 10-17		Sumter	39%	September 10-18
Highlands	100%	September 10-20		Suwannee	92%	September 10-17
Hillsborough	42%	September 10-16		Taylor	75%	September 11-17
Holmes	12%	September 9, 11-12		Union	86%	September 9, 11-16
Indian River	80%	September 10-16		Volusia	78%	September 10-19
Jackson	9%	September 10, 11-12		Wakulla	74%	September 10-17
Jefferson	75%	September 11-17		Walton	0%	N/A
Lafayette	91%	September 9, 11-17		Washington	10%	September 11
Lake	70%	September 10-19				

Table 5: 2017 County Population and Provider Distribution in Florida.

County	2017 Population	County Designation	Acute Care Hospital or Freestanding ED	Long-term Acute Care/ Rehab Facility	Rural Hospitals
Alachua	266,309	Urban	4	2	
Baker	28,254	Rural	2		1

Bay	184,736	Urban	2	2	
Bradford	27,142	Rural	1		
Brevard	587,769	Urban	8	1	
Broward	1,934,516	Urban	20		
Calhoun	14,428	Rural			1
Charlotte	181,522	Urban	4		
Citrus	145,415	Urban	3		
Clay	212,228	Urban	3		1
Collier	372,678	Urban	4		
Columbia	69,999	Urban	3		1
DeSoto	37,241	Rural	1		1
Dixie	16,615	Rural			
Duval	937,933	Urban	14	1	
Escambia	313,249	Urban	6	1	
Flagler	109,999	Urban	3		1
Franklin	11,724	Rural			1
Gadsden	45,993	Rural	1	1	
Gilchrist	17,900	Rural			
Glades	13,580	Rural			
Gulf	16,105	Rural			1
Hamilton	14,364	Rural	1		
Hardee	27,154	Rural	1		1
Hendry	41,018	Rural	1		1
Hernando	186,704	Urban	3	1	
Highlands	103,852	Urban	3		
Hillsborough	1,426,736	Urban	16		
Holmes	19,427	Rural			1
Indian River	154,241	Urban	2	1	
Jackson	48,289	Rural	2		1
Jefferson	14,165	Rural			
Lafayette	8,602	Rural			
Lake	345,432	Urban	4		
Lee	740,000	Urban	6		
Leon	290,965	Urban	2	1	
Levy	40,276	Rural	1		1
Liberty	8,236	Rural			
Madison	18,474	Rural			1
Manatee	385,506	Urban	2		
Marion	353,339	Urban	3	1	
Martin	159,701	Urban	1	1	
Miami-Dade	2,713,295	Urban	25	1	
Monroe	76,483	Urban	2		2
Nassau	82,925	Urban	1		1
Okaloosa	203,478	Urban	3		
Okeechobee	41,275	Rural	1		1
Orange	1,355,921	Urban	15		
Osceola	353,623	Urban	5		
Palm Beach	1,470,344	Urban	14	1	1
Pasco	525,141	Urban	11		

Pinellas	968,341	Urban	17	1	
Polk	685,368	Urban	5		
Putnam	73,384	Urban	1		1
St. Johns	243,693	Urban	1		
St. Lucie	313,163	Urban	2		
Santa Rosa	174,049	Urban	2		1
Sarasota	419,680	Urban	3	2	
Seminole	462,801	Urban	5	1	
Sumter	124,995	Urban			
Suwannee	44,124	Rural	1		1
Taylor	21,781	Rural			1
Union	15,448	Rural			1
Volusia	537,868	Urban	7		
Wakulla	32,050	Rural			
Walton	68,021	Urban	2		1
Washington	24,546	Rural	1		1

Table 6: Florida Counties under Mandatory Evacuations and their Characteristics.

Country	Population	Designation	Short- and Long-term Acute Care Facilities	% Peak Power Outage
Brevard	587,769	Urban	9	86%
Broward	1,934,516	Urban	20	76%
Citrus	145,415	Urban	3	79%
Collier	372,678	Urban	4	96%
Dixie	16,615	Rural	0	75%
Duval	937,933	Urban	15	85%
Flagler	109,999	Urban	3	91%
Glades	13,580	Rural	0	67%
Hendry	41,018	Rural	1	100%
Hernando	186,704	Urban	4	62%
Indian River	154,241	Urban	3	80%
Lee	740,000	Urban	6	82%
Martin	159,701	Urban	2	82%
Miami-Dade	2,713,295	Urban	26	81%
Monroe	76,483	Rural	2	85%
Orange	1,355,921	Urban	15	62%
Palm Beach	1,470,344	Urban	15	74%
Pasco	525,141	Urban	11	71%
Pinellas	968,341	Urban	18	79%
Sarasota	419,680	Urban	5	66%
Seminole	462,801	Urban	6	93%
St. Lucie	313,163	Urban	2	74%
Sumter	124,995	Urban	0	39%
Volusia	537,868	Urban	7	78%

Table 7: Counties with Eight or More Days of Power Outages.

County	2017 Population	Designation	% Peak Power Outage	Number of Days for Power Outage	Mandatory Evacuation
Alachua	266,309	Urban	53%	9	
Baker	28,254	Rural	94%	8	
Bradford	27,142	Rural	95%	8	
Brevard	587,769	Urban	86%	8	Yes
Broward	1,934,516	Urban	76%	9	Yes
Charlotte	181,522	Urban	64%	10	
Citrus	145,415	Urban	79%	9	Yes
Collier	372,678	Urban	96%	13	Yes
Columbia	69,999	Urban	92%	8	
DeSoto	37,241	Rural	89%	10	
Dixie	16,615	Rural	75%	8	Yes
Flagler	109,999	Urban	91%	8	Yes
Gilchrist	17,900	Rural	79%	9	
Glades	13,580	Rural	67%	12	Yes
Hardee	27,154	Rural	97%	10	
Hendry	41,018	Rural	100%	15	Yes
Hernando	186,704	Urban	62%	8	Yes
Highlands	103,852	Urban	100%	11	
Lafayette	8,602	Rural	91%	8	
Lake	345,432	Urban	70%	10	
Lee	740,000	Urban	82%	12	Yes
Levy	40,276	Rural	73%	9	
Madison	18,474	Rural	67%	8	
Manatee	385,506	Urban	63%	9	
Marion	353,339	Urban	76%	9	
Miami Dade	2,713,295	Urban	81%	11	Yes
Monroe	76,483	Rural	85%	19	Yes
Nassau	82,925	Urban	98%	10	
Okeechobee	41,275	Rural	96%	8	
Orange	1,355,921	Urban	62%	10	Yes
Osceola	353,623	Urban	43%	9	
Palm Beach	1,470,344	Urban	74%	8	Yes
Pinellas	968,341	Urban	79%	8	Yes
Polk	685,368	Urban	66%	10	
Putnam	73,384	Urban	89%	9	
St. Johns	243,693	Urban	100%	9	
Sarasota	419,680	Urban	66%	10	Yes
Seminole	462,801	Urban	93%	10	Yes
Sumter	124,995	Urban	39%	9	Yes
Suwannee	44,124	Rural	92%	8	
Volusia	537,868	Urban	78%	10	Yes
Wakulla	32,050	Rural	74%	8	

Table 8: Data Set Description.

Timelines in 2017	Baseline: **April 1- June 30 (Q2)** Comparison during hurricane: **July 1- September 30 (Q3)** Comparison post-hurricane: **October 1- December 31 (Q4).**
Individual Level	**Age (in years)**: <1; 1-17; 18-29; 30-39; 40-49; 50-64; 65-74; 75+ **Sex:** Male; Female **Payor:** Medicare; Medicaid; Commercial; Uninsured **Injury Type (ICD-10 codes):** NE; E-PCT; E-PA; E-NPA; Alcohol; Drug; Psychological **ED Stay:** Length of stay; Unadjusted costs; Copayment
County Level	**County Name:** Residence vs. ED Location **Health Systems:** Acute care and ED sites; Long-term acute care **Population:** Proportion of patients visiting ED **Extended power outage:** More than eight days of power outage **Evacuation orders:** Mandatory; Voluntary

List of Figures

Billion-dollar events to affect the U.S. from 1980 to 2019 (CPI-Adjusted)

DISASTER TYPE	NUMBER OF EVENTS	PERCENT FREQUENCY	CPI-ADJUSTED LOSSES *(BILLIONS OF DOLLARS)*	PERCENT OF TOTAL LOSSES	AVERAGE EVENT COST *(BILLIONS OF DOLLARS)*	DEATHS
Drought	26	10.1%	$249.7 CI	14.2%	$9.6	2,993†
Flooding	32	12.4%	$146.5§ CI	8.3%§	$4.6§	555
Freeze	9	3.5%	$30.5 CI	1.7%	$3.4	162
Severe Storm	113	43.8%	$247.8 CI	14.1%	$2.2	1,642
Tropical Cyclone	44	17.1%	$945.9 CI	53.9%	$21.5	6,502
Wildfire	17	6.6%	$84.9 CI	4.8%	$5.0	347
Winter Storm	17	6.6%	$49.3 CI	2.8%	$2.9	1,048
All Disasters	**258**	**100.0%**	**$1,754.6** CI	**100.0%**	**$6.8**	**13,249**

†Deaths associated with drought are the result of heat waves. (Not all droughts are accompanied by extreme heat waves.)
§Flooding statistics do not include inland flood damage caused by tropical cyclone events.
The confidence interval (CI) probabilities (75%, 90% and 95%) represent the uncertainty associated with the disaster cost estimates. Monte Carlo simulations were used to produce upper and lower bounds at these confidence levels (Smith and Matthews, 2015).

Figure 2: Billion-dollar events affecting the U.S., 1980-2019.

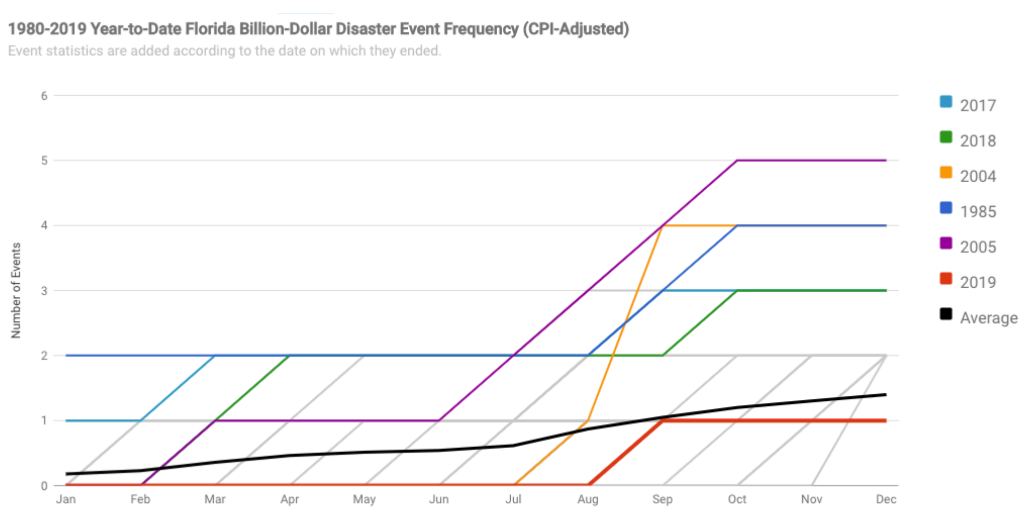

Figure 3: Frequency of billion-dollar disaster events in Florida, 1980-2019.

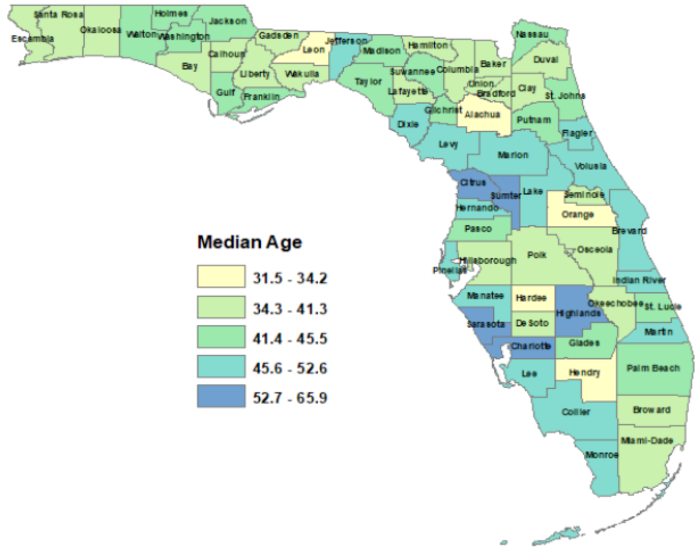

Figure 4: Median Age of Floridians as of April 1, 2018.

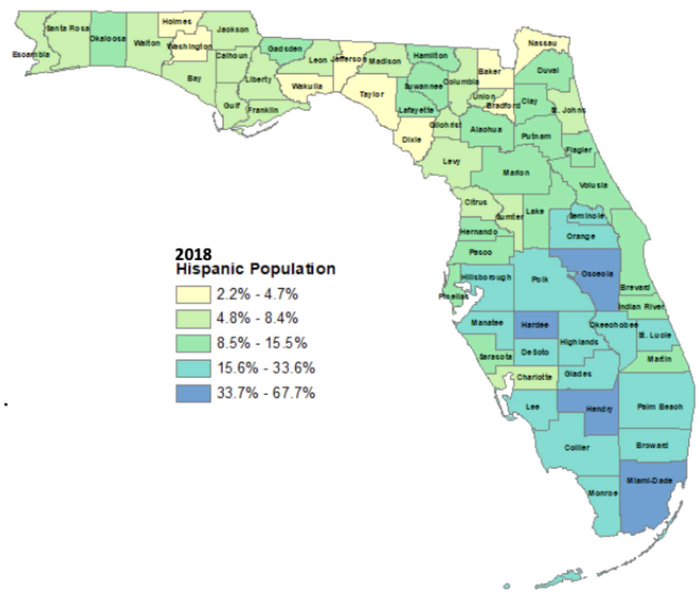

Figure 5: Florida's Hispanic Population by County in 2018.

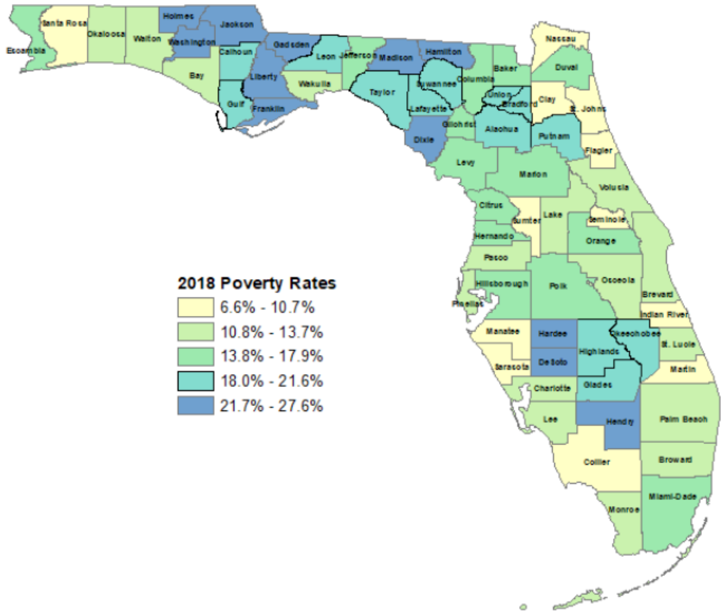

Figure 6: 2018 Poverty Rates in Florida by County.

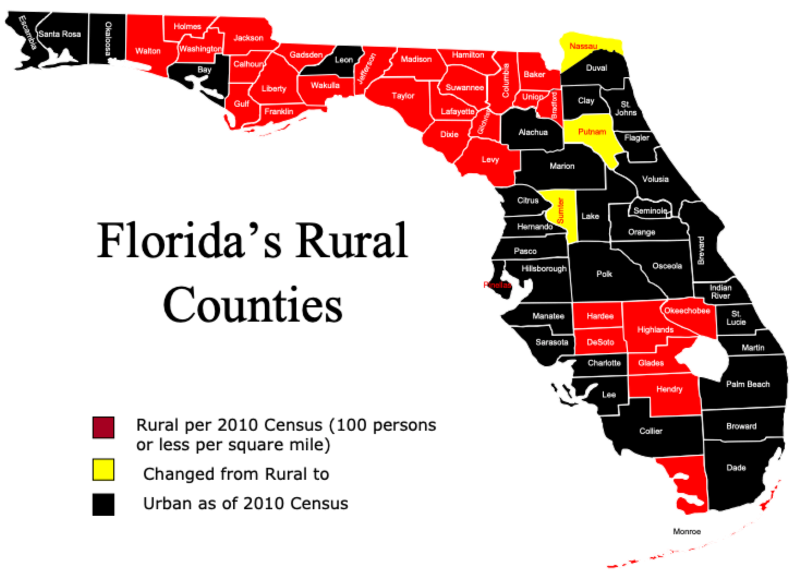

Figure 7: Rural versus Urban Designation Based on 2010 Census Data.

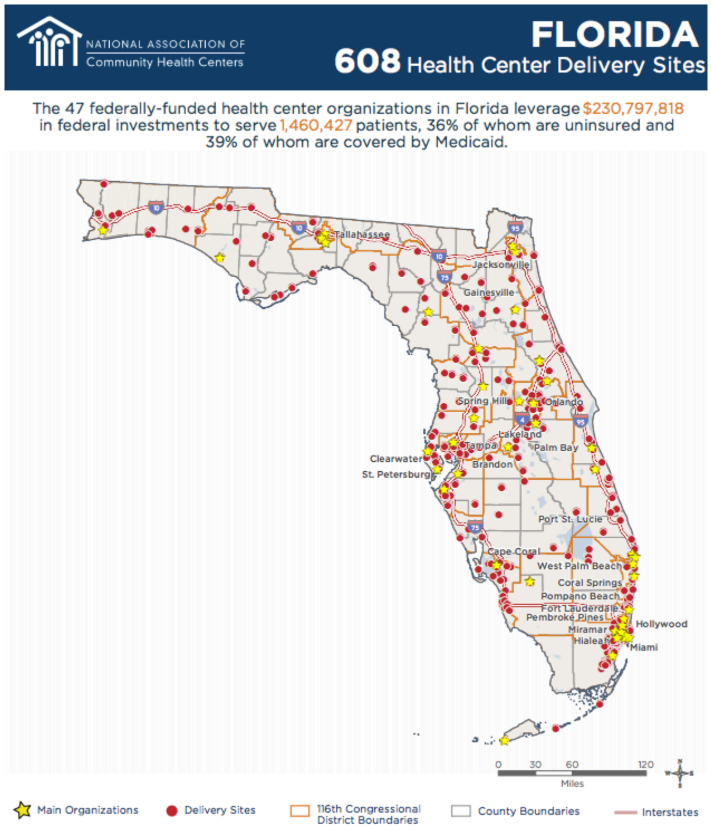

Figure 8: Distribution of federally-funded health centers in Florida.

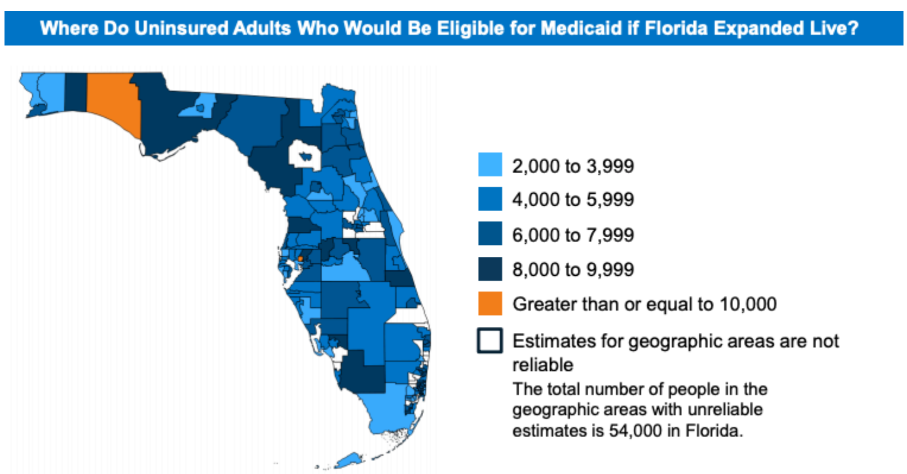

Figure 9: Distribution of Uninsured Adults in Florida.

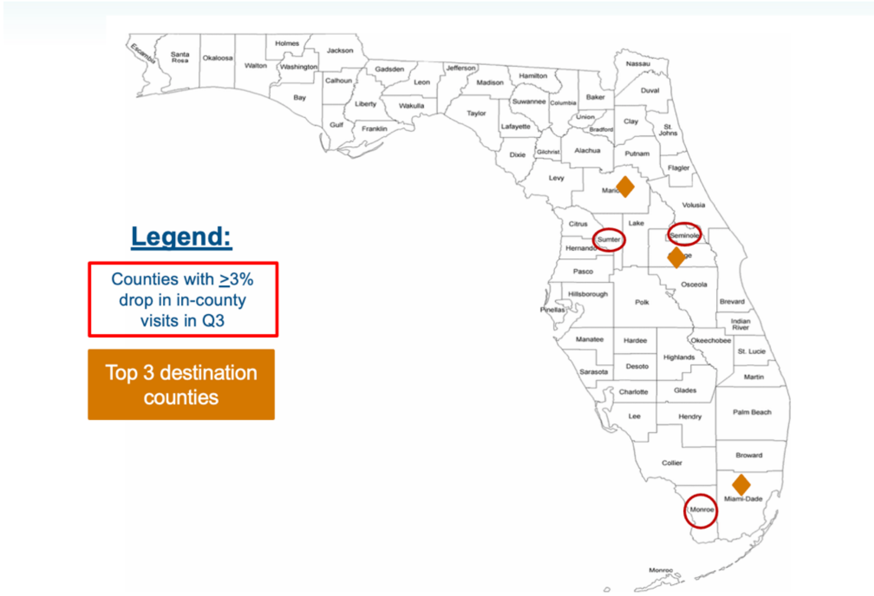

Figure 10: Top Destinations for Patients in Mandatory Evacuation Counties with Over 3% Drop in In-County Visits in Q3.

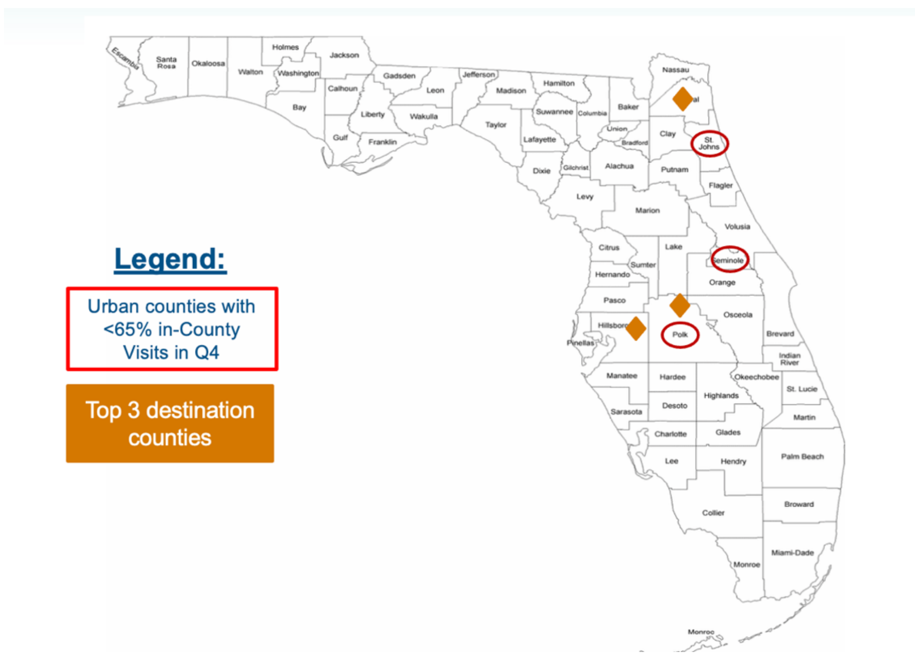

Figure 11: Top Destinations for Patients in Extended Power Outage Urban Counties with <65% In-County Visits in Q4.

References

Agency for Healthcare Research and Quality (AHRQ) (2018). *Data resources*. Retrieved from https://www.ahrq.gov/data/resources/index.html.

Alwashmi, M. F. (2020). The use of digital health in detection and management of COVID-19. *International Journal of Environmental Research and Public Health 17*. Doi: 10.3390/ijerph17082906.

Amadeo, K. (2019, August 1). Rising sea level effects, projections, and solutions. *The Balance*. Retrieved from https://www.thebalance.com/sea-level-rise-and-climate-change-4158037.

American Hospital Directory (2020). *Table of search results: Florida*. Retrieved from https://www.ahd.com/list_cms.php?submitted=Submit&mname=&mcity=&mstate%5B%5D=FL&mzip=&mphone=&fipscounty%5B%5D=.

Andrews, R. J., & Quintana, L. M. (2015). Unpredictable, unpreventable and impersonal medicine: Global disaster response in the 21st century. *The EPMA Journal 6*(2). Doi: 10.1186/s13167-014-0024-9.

Augusterfer, E. F., Mollica, R. F., & Lavelle, J. (2018). Leveraging technology in post-disaster settings: The role of digital health/telemental health. *Current Psychiatry Reports 20*(88). https://doi.org/10.1007/s11920-018-0953-4.

Ballard, D. W., Price, M., Fung, V., et al. (2010). Validation of an algorithm for categorizing the severity of hospital emergency department visits. *Medical Care 48*(1), 58-63. Doi: 10.1097/MLR.0b013e3181bd49ad.

Bitterman, N., & Zimmer, Y. (2018). Portable health care facilities in disaster and rescue zones: Characteristics and future suggestions. *Prehospital and Disaster Medicine*. Doi: 10.1017/S1049023X18000560.

Bunnell, B. E., Davidson, T., M. Dewey, D., et al. (2017, May). Rural and urban/suburban families' use of a web-based mental health intervention. *Telemedicine and e-Health*. Doi:10.1089/tmj.2016.0153.

Campo-Flores, A., De Avila, J., & Lovett, I. (2017, September 11). Irma weakens to tropical storm after lashing Florida. *The Wall Street Journal*. Retrieved from https://www.wsj.com/articles/irma-hits-florida-as-category-4-hurricane-1505045357?mod=djem10point.

Cava, D. L. (2017, November). *Hurricane Irma report and recommendations.* Miami-Dade County Commissioner, District 8. Retrieved from https://www.miamidade.gov/district08/library/irma-after-report.pdf.

Center for Connected Health Policy (2020). *National policy: Telehealth and Medicare*. Retrieved from https://www.cchpca.org/telehealth-policy/telehealth-and-medicare.

Chan, Y-F. Y., Wang, P., et al. (2017). The asthma mobile health study, a large-scale clinical observational study using ResearchKit. *Nature Biotechnology 35*(4). Doi:10.1038/nbt.3826.

Craig, R. K. (2019). Coastal adaptation, governmental subsidized insurance, and perverse incentives to stay. *Climate Change 152*, 215-226. https://doi.org/10.1007/s10584-018-2203-5.

Crutchfield, A. S., & Harkey, K. A. (2019). A comparison of call volumes before, during, and after Hurricane Harvey. *American Journal of Emergency Medicine 37*, 1904-1906.

Davis, J. B. (2016). *Medical Fees 2017*. Los Angeles, CA: Practice Management Information Corporation.

Der-Martirosian, C., Chu, K, & Dobalian, A. (2020). Use of telehealth to improve access to care at the U.S. Department of Veterans Affairs during the 2017 Atlantic hurricane season. *Disaster Medicine and Public Health Preparedness*. Doi: 10.1017/dmp.2020.88.

Der-Martirosian, C., Griffin, A.R., Chu, K., & Dobalian, A. (2019). Telehealth at the US Department of Veterans Affairs after Hurricane Sandy. *Journal of Telemedicine and Telecare 25*(5), 310-317.

Doarn, C. R., Latifi, R., Porapatich, R. K., et al., (2018). Development and validation of telemedicine for disaster response: The North Atlantic Treaty Organization multinational system. *NewsRx*. Retrieved from https://www-proquest-com.ezproxy-v.musc.edu/docview/2116178881?OpenUrlRefId=info:xri/sid:primo&accountid=36330.

ECRI (2017, September 13). How did Florida hospitals prepare for Hurricane Irma? *ECRI Risk Management News*. Retrieved from https://www.ecri.org/components/HRCAlerts/Pages/HRCAlerts091317_Florida.aspx

Elliott, T., & Yopes, M. C. (2019). Direct-to-consumer telemedicine. *American Academy of Allergy, Asthma & Immunology*. https://doi.org/10.1016/j.jaip.2019.06.027.

Emanuel, K. (2017). Will global warming make hurricane forecasting more difficult? *American Meteorological Society*. Doi: 10.1175/BAMS-D-16-0134.1.

Federation of State Medical Boards (2021). U.S. states and territories modifying requirements for telehealth in response to COVID-19. Retrieved from https://www.fsmb.org/siteassets/advocacy/pdf/states-waiving-licensure-requirements-for-telehealth-in-response-to-covid-19.pdf.

Florida Department of Health (2018). Florida Rural Hospital Directory. Retrieved from http://www.floridahealth.gov/programs-and-services/community-health/rural-health/Florida%20Rural%20Hospitals%20Directory%20January%202018.pdf.

Florida Senate (2020). *Florida Legislature Bills*. Retrieved from https://www.flsenate.gov/Session/Bills/2017?chamber=senate&searchOnlyCurrentVersion=True&isIncludeAmendments=False&isFirstReference=False&searchQuery=disaster%20relief&citationType=FL%20Constitution&pageNumber=1.

Florida Today (n.d.). Map: Hurricane Irma power outages. Retrieved from https://data.floridatoday.com/storm-power-outages/.

French, D. M., Hall, G. A., McGeorge, T., et al., (2020). Hurricane impact on emergency services and use of telehealth to support prehospital care. *Disaster Medicine and Public Health Preparedness 14*(1), 36-43. Doi: 10.1017/dmp.2019.101.

Ghose, T. (2017, September 7). How much damage could Irma do? *Live Science*. Retrieved from https://www.livescience.com/60347-how-much-damage-could-irma-do.html.

Ginzburg, E., Zakrison, T. L., Pust, G.D., et al. (2018). Hurricane Irma: Lessons learned from a south Florida gateway level II trauma center and public health trust system. *J of Trauma Acute Care Surg 85*(3). Doi:10.1097/TA.0000000000002006.

Grover, J. M., Smith, B., Williams, J. G., Patel, M. D., Cabanas, J. G., & Brice, J. H. (2020). Novel use of telemedicine by hurricane evacuation shelters. *Prehospital Emergency Care*. Doi: 10.1080/10903127.2020.1723756.

Health Data and Management Solutions (HDMS) (2017). NYU emergency room algorithm. Retrieved from https://www1.hdms.com/content/2018/10/NYU_ER_Algorithm.pdf.

Inserra, D., Bogie, J., Katz, D. et al. (2018). *After the storms: Lessons from hurricane response and recovery in 2017*. The Heritage Foundation. Retrieved from https://www.heritage.org/sites/default/files/2018-04/SR-201.pdf.

Homeland Security Digital Library (n.d.). *Disaster Relief Act of 1974*. Homeland Security Digital Library. Retrieved from https://www.hsdl.org/c/tl/disaster-relief-act-1974/.

Issa, A., Ramadugu, K., Mulay, P. et al. (2018, August 3). Deaths related to Hurricane Irma – Florida, Georgia, and North Carolina, September 4-October 10, 2017. *Centers for Disease Control and Prevention;:Morbidity and Mortality Weekly Report 67*(30). Retrieved from https://www.cdc.gov/mmwr/volumes/67/wr/mm6730a5.htm.

Johns Hopkins University (2019). *Hospital prices in the United States: an analysis of U.S. cities and states.* Retrieved from https://www.floridatrend.com/public/userfiles/news/pdfs/hospital_prices_in_the_u.s._report.pdf.

Kaiser Family Foundation (2020). 2017 *Health insurance coverage of the total population: Florida*. Retrieved from https://www.kff.org/other/state-indicator/total-population/?currentTimeframe=1&selectedRows=%7B%22states%22:%7B%22florida%22:%7B%7D%7D%7D&sortModel=%7B%22colId%22:%22Location%22,%22sort%22:%22asc%22%7D.

Kaiser Family Foundation (2019, April). *70% of uninsured adults who would become newly eligible for Medicaid if remaining states expanded live in 4 states*. Retrieved from https://www.kff.org/uninsured/slide/70-of-uninsured-adults-who-would-become-newly-eligible-for-medicaid-if-remaining-states-expanded-live-in-4-states/.

Kaiser Family Foundation (2020, January). *Who could get covered under Medicaid expansion? State fact sheets*. Retrieved from https://www.kff.org/medicaid/fact-sheet/uninsured-adults-in-states-that-did-not-expand-who-would-become-eligible-for-medicaid-under-expansion/

Kaiser Family Foundation (2020). *Who could Medicaid reach with expansion in Florida?* [Infographic]. Retrieved from http://files.kff.org/attachment/fact-sheet-medicaid-expansion-FL.

Kaiser Family Foundation (2020, March). *The U.S. has fewer physicians and hospital beds per capita than Italy and other countries overwhelmed by COVID-19.* Retrieved from https://www.kff.org/health-costs/press-release/the-u-s-has-fewer-physicians-and-hospital-beds-per-capita-than-italy-and-other-countries-overwhelmed-by-covid-19/.

Langabeer II, J. R., Gonzalez, M. et al. (2016). Telehealth-enabled emergency medical services program reduces ambulance transport to urban emergency departments. *Western Journal of Emergency Medicine 17*(6). Doi: 10.5811/westjem.2016.8.30660.

Langabeer II, J. R., Champagne-Langabeer, T., et al. (2017). Cost-benefit analysis of telehealth in pre-hospital care. *Journal of Telemedicine and Telecare 23*(8), 747-751. Doi: 10.1177/1357633X16680541.

Lin, C. C., Dievler, A., Robbins, C., Sripipatana, A., Quinn, M., & Nair, S. (2018). Telehealth in health centers: key adoption, factors, barriers, and opportunities. *Health Affairs 37*(12), 1967-1974. Doi: 10.1377/hlthaff.2018.05125.

Longest, Jr., B. (2016). *Health Policymaking in the United States* (Sixth). Chicago, Illnois: Health Administration Press.

Lurie, N., & Carr, B. G. (2018). The role of telehealth in the medical response to disasters. *JAMA Internal Medicine 178*(6).

Mitsova, D., Esnard, A-M., Sapat, A., & Lai, B. S. (2018). Socioeconomic vulnerability and electric power restoration timelines in Florida: The case of Hurricane Irma. *Natural Hazards 94*, 689-709. https://doi.org/10.1007/s11069-018-3413-x.

National Aeronautics and Space Administration (2018). *Global climate change: Scientific consensus*. Retrieved from https://climate.nasa.gov/scientific-consensus/.

National Aeronautics and Space Administration (2018). *Global climate change: Scientific consensus* [Infographics]. Retrieved from https://climate.nasa.gov/scientific-consensus/.

National Aeronautics and Space Administration (2020). *Global climate change: The effects of climate change.* Retrieved from https://climate.nasa.gov/effects/.

National Associations of Community Health Centers (2019). *Health center resource clearing house*. Retrieved from https://www.healthcenterinfo.org/.

National Associations of Community Health Centers (2019). *Florida health center delivery sites* [Infographic]. Retrieved from http://www.nachc.org/wp-content/uploads/2019/02/Florida.pdf.

NYU Wagner (n.d.). *Faculty and research: background and introduction*. Retrieved from https://wagner.nyu.edu/faculty/billings/nyued-background.

Pamplin, J. C., Davis, K. L., et al. (2019). Military telehealth: A model for delivering expertise to the point of need in austere and operational environments. *Health Affairs 38*(8). Doi: 10.1377/hlthaff.2019.00273.

Perkins, M. D., Dye, C., et al. (2017). Diagnostic preparedness for infectious disease outbreaks. *Lancet 390*, 2111-2114. http://dx.doi.org/10.1016/S0140-6736(17)31224-2.

Price, M. Yuen, E. K., et al. (2015). Access and completion of a web-based treatment in a population-based sample of tornado-affected adolescents. *Psychological Services 12*(3), 283-290. http://dx.doi.org/10.1037/ser0000017.

Radcliff, T. A., Chu, K., Der-Martirosian, C., & Dobalian, A. (2018). A model for measuring ambulatory access to care recovery after disasters. *JABFM 31*(2).

Rolston, D. M., & Meltzer, J. S. (2015). Telemedicine in the intensive care unit: Its role in emergencies and disaster management. *Critical Care Clinical Journal 31*, 239-255. http://dx.doi.org/10.1016/j.ccc.2014.12.004.

Sexton, C., & Saunders, J. (2019, June 26). *Florida gets new health care laws, bringing some big changes*. WLRN 91.3. Retrieved from https://www.wlrn.org/health-care/2019-06-26/florida-gets-new-health-care-laws-bringing-some-big-changes#stream/0.

Simpson, A. N., & Simpson, K. N. (2018, June). Comparison of charge to payment ratios across states, payers, and DRGs [Abstract]. *Academy Health, Annual Meeting Abstract #27207*.

Smith, A. B., & Mathews, J. L. (2020). *Billion-dollar weather and climate disasters: Summary stats.* National Centers for Environmental Information. Retrieved from https://www.ncdc.noaa.gov/billions/summary-stats.

Team Complete (2020). Hurricane Irma: The landfall, the aftermath, the recovery. Retrieved from https://www.teamcomplete.com/hurricane-irma/.

The Centers for Disease Control and Prevention (CDC) (2015). *International classification of diseases, (ICD-10-CM/PCS) transition – background*. Retrieved from https://www.cdc.gov/nchs/icd/icd10cm_pcs_background.htm.

The Florida Legislature (2020, January). Demographic overview and population trends. The Office of Economic and Demographic Research. Retrieved from http://edr.state.fl.us/Content/population-demographics/data/index-floridaproducts.cfm.

Turner, A. K., Edison, L., et al. (2019). Monitoring the health of public health responders: Development and use of the responder safety, tracking, and resilience system (R-STaR) for Hurricane Matthew. *Disaster Medicine and Public Health Preparedness 13*(1), 74-81. Doi: 10.1017/dmp.2018.102.

United States Census Bureau (2020). County population totals 2010-2019. Retrieved from https://www.census.gov/data/datasets/time-series/demo/popest/2010s-counties-total.html#par_textimage_739801612.

United States Department of Health and Human Services, The Centers for Medicare and Medicaid Services (2019). National health expenditure data. Retrieved from https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/NationalHealthAccountsHistorical.

United States Department of Commerce, The National Oceanic and Atmospheric Administration (2020). *Billion-dollar weather and climate disasters: Summary stats* [Infographic]. Retrieved from https://www.ncdc.noaa.gov/billions/summary-stats.

United States Department of Commerce, The National Oceanic and Atmospheric Administration (2020, August 6). *Extremely active hurricane season possible for Atlantic Basin*. Retrieved from https://www.noaa.gov/media-release/extremely-active-hurricane-season-possible-for-atlantic-basin.

United States Department of Commerce, The National Oceanic and Atmospheric Administration (2020). *Frequency of billion-dollar disaster events in Florida, 1980-2019* [Infographic]. Retrieved from https://www.climate.gov/news-features/blogs/beyond-data/2010-2019-landmark-decade-us-billion-dollar-weather-and-climate.

United States Department of Commerce, The National Oceanic and Atmospheric Administration (n.d.). *Irma graphics archive: 5-day forecast track, initial wind field and watch/warning graphic* [Interactive map]. Retrieved from https://www.nhc.noaa.gov/archive/2017/IRMA_graphics.php?product=5day_cone_with_line_and_wind

United States Department of Homeland Security, Federal Emergency Management Agency (2018, July 12). *2017 hurricane season FEMA after-action report*. Retrieved from https://www.fema.gov/media-library/assets/documents/167249.

University of Florida (2019). Florida estimates of population. Bureau of Economic and Business Research. Retrieved from http://edr.state.fl.us/Content/population-demographics/data/PopulationEstimates2019.pdf.

Uscher-Pines, L., Fischer, S., & Chari, R. (2016). The promise of direct-to-consumer telehealth for disaster response and recovery. *Prehospital and Disaster Medicine 31*(4). https://doi.org/10.1017/S1049023X16000558.

Uscher-Pines, L., Fischer, S., Tong, I., Mehrotra, A., Malsberger, R., & Ray, K. (2018). Virtual first responders: The role of direct-to-consumer telemedicine in caring for people impacted by natural disasters. *Journal of General Internal Medicine 33*(8), 1242-1244.

Vartorella, L. (2017, September 6). Florida hospitals prepare for Hurricane Irma: 7 things to know Wednesday. *Becker's Hospital Review*. Retrieved from https://www.beckershospitalreview.com/patient-flow/florida-hospitals-prepare-for-hurricane-irma-7-things-to-know-wednesday.html.

Wicklund, E. (2019, August 9). Florida Board of Medicine votes to abandon telehealth guidelines. mHealth Intelligence. Retrieved from https://mhealthintelligence.com/news/florida-lawmakers-bypass-payment-parity-in-new-telehealth-legislation.

Winburn, A. S., Brixey, J. J., Langabeer II, J., & Champagne-Langabeer, T. (2018). A systematic review of prehospital telehealth utilization. *Journal of Telemedicine and Telecare 24*(7), 473-481. Doi: 10.1177/1357633X17713140.

Wood, C. S., Thomas, M. R., Budd, J., et al. (2019, February). Taking connected mobile-health diagnostics of infectious diseases to the field. *Nature 566*. https://doi.org/10.1038/s41586-019-0956-2.

Yuen, E. K., Gros, K., Welsh, K. E., et al., (2016). Development and preliminary testing of a web-based, self-help application for disaster-affected families. Health Informatics Journal 22(3), 659-675. Doi: 10.1177/1460458215579292.