IMPACT OF HURRICANE MATTHEW ON
DIABETES SELF-MANAGEMENT AND OUTCOMES

by

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Abstract

INTRODUCTION: Individuals with diabetes require extensive self-management. Little is known about how a hurricane impacts diabetes self-management or outcomes and how it perpetuates health disparities in Robeson County, NC, a county where there is a high proportion of minority racial groups.

METHODS: Mixed methods were used to assess the impact of hurricanes on diabetes outcomes. Mean hemoglobin A1c (HbA1c) and frequency of diabetic ketoacidosis (DKA) from the Southeastern Regional Medical Center from 6 months before and after Hurricane Matthew (HM) were compared using Student t-tests. Individuals with diabetes ≥ age 18 in Robeson County were recruited for focus groups and administered questionnaires to understand the perceived impact of the hurricane on diabetes self-management. Healthcare providers were recruited for parallel key informant interviews.

RESULTS: 3,057 and 2,941 individuals had HbA1c measures available before and after HM, respectively. A demographic breakdown of 34.3% White, 21.7% Black or African American, and 21.4% American Indian or Alaska Native was observed in the sample representing 6 months after HM. No significant differences were found between mean HbA1c values before and after HM (before HM: mean HbA1c $8.34 \pm 1.87\%$; after HM: mean HbA1c 8.31 ± 1.93 %; $p=0.366$). The period prevalence (PP) of DKA was higher in the 6 months after HM than before (before HM: 39 cases out of 4,025 visits, PP=0.010; after HM: 87 cases out of 3,779 visits, PP=0.023; $p<0.0001$). Significant themes from preliminary qualitative results highlight a lack of access to a balanced diet and diabetes medications that occurs during hurricanes in Robeson County, NC, especially for those of low socioeconomic position (SEP).

CONCLUSIONS: Individuals with diabetes were more likely to experience DKA after Hurricane Matthew than before. Future interventions may improve outcomes via increased access to healthful foods and diabetes medications, particularly for those of low SEP.

Introduction

Diabetes mellitus refers to a group of diseases that impacts the way your body uptakes blood glucose [1]. Type 1 and type 2 diabetes are the two most prevalent types of diabetes with type 2 diabetes accounting for more than 85% of the total diabetes prevalence [2]. The increased incidence of obesity has led to an increased manifestation of type 2 diabetes, particularly in children and young adults [2]. The global prevalence of diabetes is expected to increase to 592 million by 2035 from 382 million that was observed in 2013 [2]. According to a 2017 report by the Centers for Disease Control and Prevention, more than 100 million U.S. adults (>40% of US adults) are now living with diabetes or pre-diabetes [3]. From the National Health and Nutrition Examination Survey (NHANES), Menke, et. al., found recent prevalence in total diabetes, diagnosed diabetes, undiagnosed diabetes, and prediabetes unadjusted prevalence measurements of 14.3%, 9.1%, 5.2%, and 38.0%, respectively [4]. As a major cause of both morbidity and mortality, diabetes costs in 2012 alone were estimated to be over $245 billion as a result of increased strain on healthcare resources and reduced productivity [4].

Both Type 1 diabetes (T1D) and Type 2 diabetes (T2D) are serious diseases that require extensive self-management including physical activity, diet, and the appropriate use of insulin and other medications to control blood sugar [3]. If proper treatment of diabetes does not take place, a diabetic emergency could take place called diabetic ketoacidosis [5]. It's possible that the decreasing proportion of the population with undiagnosed diabetes in recent years may be attributable to better screening techniques and better interventions available to those with diagnosed diabetes [4]. Health disparities with patient access to physicians, health system resources, and community supplies have been identified between different racial groups that directly affects diabetes self-management [6]. For type 2 diabetes, it was found that the prevalence measurements among young adults (10-19 years of age) in the United States

among American Indian, Black, and Hispanic identities were significantly higher than the prevalence for white-identifying young adults [2].

Access to adequate health insurance, specialized care, medications, and supplies have been identified as key determinants of glycemic control, and food insecurity has been associated with a higher HbA1C [7]. A key finding of the CDC 2017 report noted earlier found that "the Southern and Appalachian areas" of the United States had the highest rates of diagnosed diabetes and of new diabetes cases [3]. A Southern US county that was recently impacted by Hurricane Matthew, Robeson County, NC, has a population of 134,871, a total diabetes prevalence of 15.7%, and a demographic breakdown of 37.6% native, 26.6% white, and 24.0% black [8]. For comparison, a report by the US Census Bureau showed that the Native American or Alaska Native population makes up about 2% of the total US population [9]. From the 2017 County Health Rankings, Robeson County, NC, has the highest prevalence of adult smoking (26.8%) and homicide (20.9 homicide deaths per 100,000 people) of any county in North Carolina [3]. In addition, Robeson County, NC, has 43 primary care physicians per 100,000 people [3].

Robeson County, NC, a County in Need

According to the County Health Rankings from the NC Rural Center, Robeson County, NC, not only is ranked in the lowest quartile for weighted median household incomes, but the rural county ranked last (100th out of the 100 counties in North Carolina) in terms of health outcomes [10]. Robeson County also ranks last or near the last in North Carolina for health behaviors including the prevalence of adult smoking (27%), adult obesity (40%), and access to exercise opportunities (41%) [10]. 22% of the county is uninsured, compared to 15% for North Carolina in general and 42% of children are reportedly in poverty compared to 23% for the state as a whole [10]. A local journal article from the Robesonian stresses that these numbers represent a distress signal; this signal

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is that Robeson County is struggling with higher unemployment rates and struggling school systems [11]. The article also mentions the need for individuals to take advantage of existing programs and services to help with nutrition and health advice, so that the community as a whole will improve their health outcomes [11].

Hurricane Matthew hits Robeson County, NC

Hurricane Matthew made landfall in Robeson County on October 8th, 2016. Robeson County experienced record rainfall and loss of agriculture, livestock, and electricity following the storm [12]. When a natural disaster like a hurricane hits, access to certain resources, such as major medical centers, may be restricted [13]. According to an article published by Race Forward, the native Lumbee Tribe chief, Harvey Godwin, "Hurricane Matthew affected 50,000 of the 55,000 members impacting access to food, water, and other necessities" [14]. As thousands of people were left wondering where their next shower or meal would come from, emergency shelters were set up around the county for those most impacted by the storm [15]. Two years after Hurricane Matthew hit the Robeson County area, a second storm, Hurricane Florence, impacted the still recovering community [16]. Angered citizens of Lumberton, NC, have blamed a local rail company for many of the damages from Hurricane Florence because a poorly placed rail line underneath Interstate-95 [17]. A study conducted by the North Carolina Department of Transportation and North Carolina Emergency Management found that a floodgate (instead of the rail line) built there would reduce damages from a Hurricane Matthew-like storm by more than 80% [17].

Impacts of Climate Change and Hurricane Impacts: Frequency and Strength

A hurricane is defined as a rotating storm that builds momentum and strength over tropical waters [18]. Hurricanes form from deep beneath the ocean surface

and the temperatures at these deep levels are measured as the Ocean Heat Content. The Ocean Heat Content has experienced drastic increases since 1970, and shown some correlation, on multi-year analysis, between the Atlantic sea surface temperature [19]. In a study conducted by NOAA (National Oceanic and Atmospheric Administration) that analyzed sea surface temperatures and hurricane activity over the past century, they found a positive correlation between these two metrics [19]. Hurricanes have a classification system measured by the Saffir-Simpson scale (larger the category, the worse and more major the storm) that's used when a new storm is identified [18]. The most severe hurricanes are classified as Category 5; in the last decade, there have been only three recorded (one of which was Hurricane Matthew) [18]. Since every major hurricane over the last century has been given a classification of strength with the Saffir-Simpson scale, it's possible to measure whether hurricanes have been getting worse in frequency and strength [18]. In the study conducted by NOAA, evidence is still unclear as there is speculated missing hurricane frequency data from a lack of measurement tools in the first few decades of the study [19]. Global greenhouse warming is expected to intensify and increase the rainfall of hurricanes within the next century [19].

Rural North Carolina and Access to Resources

The definition of what is considered to be a rural area has been debated in recent years, but the North Carolina Rural Center attempts to define "rurality" by labeling counties as either a urban (750 people or more per square mile), Suburban (250-750 people per square mile), or rural (less than 250 people per square mile) according to number of people per square mile [20]. Rural hospital closures, lack of specialists, and low-quality healthcare are all identified as disparities between the rural and urban healthcare landscapes in North Carolina [21]. The UNC Shep's Center Rural Health Snapshot identifies other variables that may play a part in these disparities, like education rates: the percentage of

adults aged 25- 44 with some post-secondary education is 53.7 and 64.9 for rural and urban areas, respectively [22].

Food insecurity, suicide rates, and preventable hospitalizations are all higher in rural communities as well [22]. Staggering differences in access to clinical care exist in rural communities, like the number of primary care physicians per 100,000 people in 2013 was measured to be 55.1 compared to 79.3 in urban areas [22]. The percentage of those uninsured under the age of 65 is measured to be 14.5% of the population when compared to 13.4% in urban areas, and those reporting physical inactivity (percentage of those reporting no physical activity in 2012) was 27.8%and 22.3% for rural and urban communities, respectively. Many of these places have fewer places to exercise including gyms or parks [23]. These disparities are resulting in health inequities and worse outcomes for those living in rural areas [21]. About 40% of North Carolinians live in one of the 80 rural counties in North Carolina with a population density of 250 people per square mile or less, defined by the North Carolina Department of Commerce [23]. There have been 5 rural hospital closures since 2010, according to the UNC Shep's Center, and when a hospital closes, thousands of jobs are also leaving the surrounding community, further perpetuating disparities [23].

Understanding Impacts of Hurricane Matthew on Robeson County, NC

Although North Carolina has experience with coastal storms, Matthew did not behave in the same way as many Atlantic hurricanes [24]. Most storms hit the southeastern beaches of North Carolina and travel upwards towards the Outer Banks, but Hurricane Matthew went up through South Carolina directly into the inland portion of southeastern North Carolina before returning to the Atlantic Ocean [24]. Compounding to the situation, the storm was slow moving and hit some of the poorest counties in the state [24]. Hurricane Matthew took the lives of 28 people in North Carolina and caused catastrophic flooding in the

southeastern parts of the state [24]. According to the National Weather Service, Hurricane Matthew was the most powerful category 1 hurricane of 2016 with winds up to 150 mph [25]. The Lumber (Lumbee) River in downtown Lumberton crested at 24.39 feet on October 9th, the highest in history, causing highways to close down and thousands of people to be displaced from their homes [25]. Water from the Lumber River flooded the Lumberton water treatment plant that shut down the city's municipal water supply for weeks to come [25]. As a result of Hurricane Matthew, the U.S. Department of Housing and Urban Development has approved a total of $404 million to be used for rebuilding seriously damaged housing, businesses and critical infrastructure in North Carolina [26].

Barriers to Care for Individuals with Diabetes During a Natural Disaster

Children and adults with diabetes are tasked with a daily care regimen that includes blood glucose monitoring, insulin administration, meal planning, and regular screening for diabetes-related complications [3]. A monumental study called the Diabetes Control and Complications Trial of 1993 showed how glycemic control through intense insulin therapy for preventing microvascular and macrovascular complications had significant benefits to prevention of diabetes-related health outcomes [27]. Landmark clinical studies demonstrate the need to control risk factors like hyperglycemia, hyperlipidemia, and hypertension to prevent or delay the onset of complications related to diabetes [28]. Many barriers to diabetes care have been identified including socioeconomic position, health insurance and out of pocket costs, physical access to services in rural versus urban settings, transportation, availability of health care personnel, and receipt of preventative care [28]. Lack of access to resources are highlighted as an overarching barrier to care for many individuals with diabetes and natural disasters only worsen this phenomenon [13].

Fonseca et.al have examined the effects from Hurricane Katrina on diabetes self-management and found that people had difficulty accessing medication and

supplies, resulting in inappropriate insulin and analog levels being used [13]. They found that despite resources available on the ADA website regarding what to do in an emergency situation (like living through a hurricane), those in emergency shelters rarely had access to the internet to reach those documents [13]. Similarly, a study examined the effects from the Kobe Earthquake in Japan, and found that individuals with diabetes often changed their diabetes medication as a result of the natural disaster [29]. The follow-up study 3 to 4 months after the Kobe Earthquake revealed peaking HbA1c levels, likely from lifestyle, diet, and access to medication changes [29]. Research has shown that individuals with diabetes experience significant adverse health effects when faced with natural disasters, including foot ulcers, amputations, and worsened control of HbA1c [30]. These studies that examined the impact of a natural disaster on the health and outcomes of individuals with diabetes found that there was increased glycemic stress as a result of the natural disaster [13, 31].

Role of Emergency Shelters in Self-Management for Individuals with Diabetes

When Hurricane Matthew hit North Carolina, health care providers from hospitals, clinics, and pharmacies joined together to provide a triage, consultation, and medications to patients living in emergency shelters [15]. North Carolina requested and received 20 public health nurses from Tennessee alone all within a 3 hour period of time [24]. Like Hurricane Katrina, the support provided by health care providers in emergency shelters helped offset the amount of 911 emergency calls and local emergency department visits [15]. Limited health literacy of patients in emergency shelters around Robeson County, NC, during the landfall of Hurricane Matthew is noted as a barrier to optimal healthcare [15].

The emergency shelter pharmacies that were set up brought in donated medications from various hospitals, pharmacies, and community members to

provide no cost medications for patients needing them [15]. When Hurricane Matthew hit North Carolina, Governor Pat McCrory issued a state of emergency, which led to many changes in healthcare policy like expanding pharmacists' ability to ensure patients receive the care they need by overriding the "refill too soon" prohibition [15].

Although many barriers to care for individuals with diabetes have been identified in many landmark studies, the impact Hurricane Matthew or Hurricane Florence made on self-management practices and outcomes for individuals with diabetes in Robeson County, North Carolina is not fully understood (Assembly, 2016). To address this gap, I collected qualitative data from individuals with diabetes who lived through this storm and Hurricane Florence, and use EHR data collected from the Southeastern Regional Medical Center to see if diabetes self-management and outcomes have been negatively impacted following landfall of Hurricane Matthew for individuals with diabetes. Therefore the specific aims for this study are as follows:

Specific Aims & Hypotheses

Aim 1: To characterize how Hurricane Matthew and Hurricane Florence affected perceived access to reliable food, medications, and supplies as described by individuals with diabetes in Robeson County, NC.

1a: Access to supplies, medication, and reliable food sources for individuals with diabetes will have decreased from before to after Hurricane Matthew.

1b: Individuals with diabetes will have better prepared for Hurricane Florence after experiencing Hurricane Matthew.

Aim 2: To quantify the impact Hurricane Matthew had on diabetes outcomes in Robeson County, NC using a one year time span centered around Hurricane Matthew and cut into two time periods (6 months each) to be compared as two cross sectional panels.

2a: Clinical outcomes (mean HbA1c and frequency of DKA) after Hurricane Matthew will be significantly higher than that before Hurricane Matthew.

BRIEF METHODS

Setting

Robeson County, NC, has a population of 134,871, a total diabetes prevalence of 15.7%, and a demographic breakdown of 37.6% Native American, 26.6% White, and 24% Black [8]. From the 2017 County Health Rankings, Robeson County, NC, has the highest prevalence of adult smoking (26.8%) and homicide (20.9 homicide deaths per 100,000 people) of any county in North Carolina [3]. According to the North Carolina Rural Center on Health Rankings and Living Wage, Robeson County ranks last out of all counties in North Carolina in terms of health outcomes and falls in the lowest quartile of all counties in terms of weighted average household income [20].

Mixed methods, composed of focus groups, key informant interviews, and electronic health record (EHR) data analysis, were used to understand the impact of Hurricane Matthew diabetes self-management and outcomes shown in **Figure 1**.
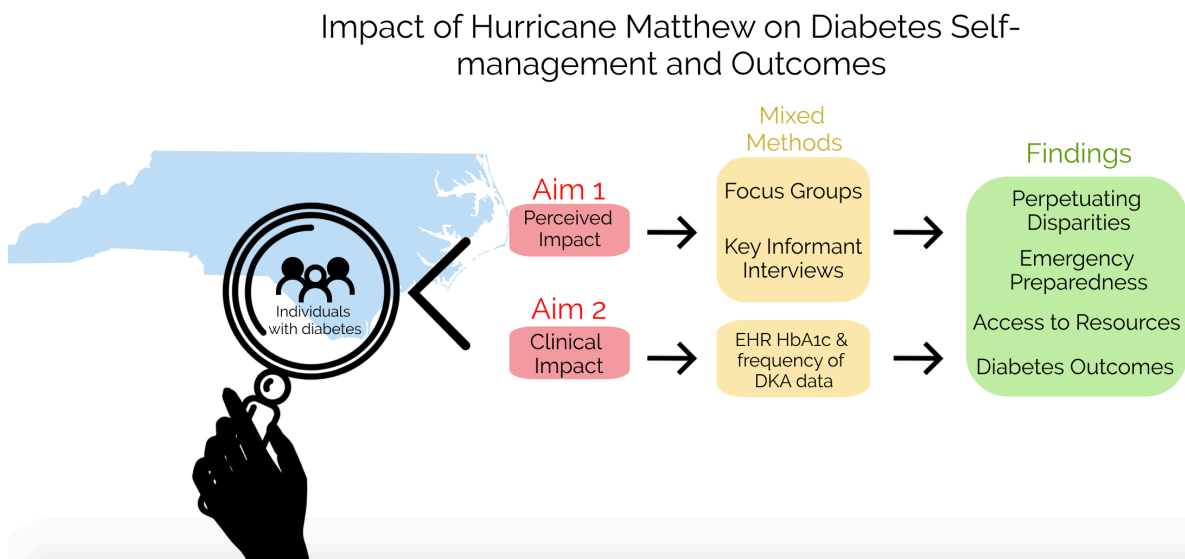

Impact of Hurricane Matthew on Diabetes Self-management and Outcomes

Figure 1. Overview of approach to understand the impact Hurricane Matthew had on individuals with diabetes. Three main approaches (2 qualitative and 1 quantitative) were explored in mixed methods paradigm.

Focus Groups

Focus Group Procedure

Individuals signed up to participate in one of three different focus groups. The groups were conducted separately in different parts of Lumberton, NC, and included individuals with diabetes over the age of 18 from Robeson County that experienced Hurricane Matthew and/or Hurricane Florence. Two religious-based organizations (First Baptist Church off West 2nd Street and the First Baptist Church off Walnut Street) were locations of the focus groups in Lumberton, NC. A third focus group was scheduled at the Southeastern Regional Medical Center, but due to low participation (one individual), their response was not included in focus group data and treated more like a key informant interview.

Participants signed a consent form for both participating in the focus group and for audio recording the conversation that was about to take place. A paper Emergency Preparedness Questionnaire was administered to all participants to gain an individual level understanding of perceived impacts before the focus group discussions began. Comments were made before each focus group started about the importance of hearing diverse perspectives and answers from all focus group participants. An emphasis was also made on the voluntary nature of participating in a focus group. Focus groups were then audio recorded using a standard audio recorder. A semi-structured focus group guide was developed and utilized for each focus group session around 4 main qualitative questions: How did Hurricane Matthew impact perceived access to food, water, and medications? How did Hurricane Florence impact perceived access to food, water, and medications? How did Hurricane Matthew impact preparedness for

Hurricane Florence? And, what resources would be helpful in the future for individuals with diabetes during a hurricane in Robeson County, NC?

Questions and discussions centered around perceived impacts of Hurricane Matthew on those with diabetes. To understand how Hurricane Matthew may have impacted the way individuals with diabetes prepared for future hurricanes (i.e. Hurricane Florence), questions relating to preparation for the more recent, Hurricane Florence, was asked. As an attempt to limit recall bias, Hurricane Florence was discussed first (more recent) as to pull as much information from individual's recent memory as possible, before discussing Hurricane Matthew. In addition, individuals participating were given time between discussing each hurricane to remember back to the correct period of time and decipher their hurricane experiences.

Dr. Cherry Beasley was present for the first focus group and provided diabetes education and advice for participants that had questions about diabetes-specific preparation for a hurricane or other natural disasters. Focus group participants were then compensated with a $25.00 gift card for their time. Focus groups lasted about an hour and a half, and study personnel had no further communication or follow up with focus group participants.

Recruitment

The study was comprised of 24 focus group participants recruited from two faith-based organizations (First Baptist Church on Walnut Street and the First Baptist Church on W 2nd Street), the Robeson County Church and Community Center, the Southeastern Regional Diabetes Clinic (Health Mall), and the Southeastern Regional Medical Center. Verbal consent from all recruitment locations was provided before flyers were left in lobby areas. Local representatives at faith-based organizations and community centers were asked to mention the study during their services with a recruitment script. Individuals that did not have

diabetes, did not live in Robeson County during Hurricane Matthew, were not over the age of 18 at the start of the study, were unable to read and write in the English language, and were involuntarily detained or incarcerated during the study were excluded from participation in the focus groups. If community members with diabetes were interested in participating in the study, they contacted Kevin Travia via the contact information provided on the flyer passed out at recruitment locations. The selection process was equitable among all relevant demographic groups as the flyers were passed out at public spaces accessible to as many people as possible in the target population.

Consent

The study brochure (flyer) and consent form were verbally reviewed with all focus group participants, and all questions about the study were answered before informed consent was agreed to. Participants also agreed to be audio recorded during the focus groups. Study staff ensured all participants signed the paper consent document before continuing with the study.

Emergency Preparedness Questionnaire

Following consent, a pre- focus group questionnaire was used to collect demographic, lifestyle, and clinical variables as well as understanding accessibility to reliable food, medications, and supplies for individuals with diabetes during both Hurricane Matthew and Hurricane Florence. Body Mass Index (BMI) was calculated using an online BMI calculator from the National Institute of Health [10]. Questions also targeted emergency preparedness as it relates to food, medications, and supplies prepared before Hurricane Matthew. To understand how Hurricane Matthew may have impacted the way individuals with diabetes prepared for Hurricane Florence, questions relating to preparation for the more recent, Hurricane Florence, was asked. Barriers, as they apply to

access to healthcare and diabetes medications and supplies, were assessed in relation to Hurricane Matthew and Hurricane Florence.

Analysis

Standard transcription methods were used to transcribe each focus group from their audio files into word documents. Documents were then analyzed using standard qualitative analysis. Focus group transcriptions were broken down into individual statements and main themes were labeled. Each quote falling into main themes were then further labeled into subthemes and compiled into a qualitative table. This table included the theme, subtheme, location of the focus group (North or South Lumberton focus group), and the quote from each statement. A second study staff member repeated this process for accuracy purposes of theme extraction, and results were compared.

Key Informant Interviews

Key Informant Interview Procedure

The key informant interviews took place with the goal of understanding the healthcare provider and community leader perspective around perceived impacts on those with diabetes during Hurricane Matthew and Florence. Consent waivers for participation and audio recording were filled out, signed, and returned to the student staff member prior to the start of the interviews. The interviews followed standard methodology, including the use of a pre-written set of guiding questions consistent for all participants. Questions around specific experiences with health related barriers for individuals with diabetes during both Hurricane Matthew and Hurricane Florence were asked. Interview sessions were reviewed for common themes. Themes were extracted using standard qualitative analysis techniques, and subthemes were then identified from theme-labeled quotes. No further follow up or communication with key informant

interview participants took place, unless they were involved in another aspect of the study.

Recruitment

There were 5 individuals in the community that were selected for participation in the key informant interviews based on the role they played in caring for individuals with diabetes in the community before, during or after either Hurricane Matthew or Hurricane Florence. Various healthcare providers from the Southeastern Health System made suggestions around which individuals would be apt to want to interview with the study and provide their experiences during the storms. Dr. Cherry Beasley from the Nursing Department at UNC- Pembroke provided invaluable advice when recruiting individuals for their participation. Individuals were asked to participate if they lived in Robeson County during Hurricane Matthew and were an active healthcare provider for individuals with diabetes or were in a leadership role in the community (i.e. city council members and community center leaders). Only those over the age of 18 at the start of the study were contacted for participation in the key informant interview. No incentive was provided to those participating in the key informant interviews, and it was made clear at the start of each key informant interview about the voluntary nature of participating in any or all questions.

Consent

The study brochure (flyer) and consent form were verbally reviewed with all key informant interview participants, and all questions about the study were answered before informed consent was agreed to. Study staff ensured all participants signed the paper consent document before continuing with the study.

Analysis

Standard transcription methods of key informant interview audio recordings to a word document took place. Documents were then analyzed using standard qualitative analysis. Themes were found throughout all informant comments and quotes were identified. Key informant interview transcriptions were broken down into individual statements and labeled with one of the main themes. Each theme was then further labeled into subthemes and compiled into a qualitative table. This table included the theme, subtheme, and role that the individual had in the management of those with diabetes. Quotes from the interviews, pertinent to each main theme, were included in the results table and organized based on theme.

Electronic Health Records

Individuals with Type 1 or Type 2 diabetes were included in the data dump from Southeastern Regional Medical Center looking at HbA1C and frequency of DKA-related hospital visits, among other demographic data, from before to after Hurricane Matthew. A one-year time span around Hurricane Matthew, 6 months before through 6 months after, was split into two cross sectional panels (6 months before the storm up until Hurricane Matthew and Hurricane Matthew through 6 months after the storm). To analyze changes in clinical outcomes for those with diabetes, both mean HbA1c and frequency of DKA were compared between these two cross sectional panels. Student t-tests analyzed whether statistically significant changes in prevalent cases of DKA related ER visits and mean HbA1C changes occurred from before to after Hurricane Matthew.

Inclusion Criteria

Only residents of Robeson County that were over the age of 18 were included in the data collection and further statistical analysis. Any person who was pregnant during the time period under review was not included in this study. It was requested that those with the following ICD-10 codes be used as inclusion

criteria to include those with diabetes: ICD-10: E08.xx, E09.xx, E10.xx, E11.xx, E13.xx, P70.2, O24.0, O24.1, O24.3, and O24.8. Since many individuals were included with an HbA1c less than 3.5 and the guidelines for what is considered diabetes, according to the American Diabetes Association, is a HbA1c level above 6.5, all participants with an HbA1c less than 6.5 were excluded from this calculation [32].

The next chapter is the manuscript to be submitted for publication in the North Carolina Medical Journal.

IMPACT OF HURRICANE MATTHEW ON DIABETES SELF-MANAGEMENT AND OUTCOMES

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Abstract

BACKGROUND

Individuals with diabetes require extensive self-management. Little is known about how Hurricane Matthew (HM) impacted diabetes self-management and outcomes in Robeson County, North Carolina.

METHODS

Mixed methods were used to assess the impact of HM on diabetes outcomes. Individuals with diabetes in Roberson County were recruited for focus groups and administered questionnaires to understand the perceived impact on diabetes self-management and access to resources. Healthcare providers were recruited for parallel key informant interviews. Mean hemoglobin A1c (HbA1c) and frequency of Diabetic Ketoacidosis (DKA) from the Southeastern Regional Medical Center from 6 months before and after HM were compared using Student t-tests.

RESULTS

Qualitative results highlight a limited access to a balanced diet and medications. No significant differences were found between mean HbA1c values before and after HM (before HM: mean HbA1c 8.34 ± 1.87%; after HM: mean HbA1c 8.31 ± 1.93 %; p=0.366). A demographic breakdown of 34.25% White, 21.70% Black or African American, and 21.38% American Indian or Alaska Native was observed. The period prevalence (PP) of DKA was higher in the 6 months after HM than before (before HM: 39 cases out of 4,025 visits, PP=0.010; after HM: 87 cases out of 3,779 visits, PP=0.023; p<0.0001).

LIMITATIONS

Limitations include non-random sampling and limited sample sizes. Also, cross sectional panel approach didn't follow the same individuals over time.

CONCLUSIONS

Individuals with diabetes were more likely to experience poor diabetes outcomes after HM than before. Future interventions may improve outcomes via increased access to diabetes-compliant foods and medications.

Despite significant efforts to curb rising incidence of diabetes cases in the United States, the Centers for Disease Control and Prevention (CDC) has estimated that in 2015 1.5 million new cases of diabetes were diagnosed in US adults over the age of 18 alone [1]. The CDC further reported more than 100 million U.S. adults (>40% of US adults) are now living with diabetes (>30 million) or pre-diabetes (>84 million), a condition if untreated often leads to type 2 diabetes within 5 years. Geographically, the highest incidence of newly diagnosed diabetes cases can be found in the Southern and Appalachian areas of the United States, particularly in rural communities [1]. Access to nutritious food, health insurance, specialized care, and diabetes medications and supplies have been identified as key determinants of glycemic control for individuals with diabetes [2]. One study examining the impact of Hurricane Katrina on those with diabetes found that access to major medical centers, food, water, and medications were limited leading to significant effects on diabetes self-management and outcomes [3]. From the Kobe Earthquake researchers found that those with diabetes had to change their diabetes medication during the disaster [4].

Following Hurricane Matthew, thousands of people were forced to evacuate from their homes as flooding waters decimated many towns all up the Eastern Seaboard of the United States [5]. The storm made significant impact in Robeson County, NC, on October 8th, 2016, where more than 26 people lost their lives and an estimated $4.8 billion worth of damages were sustained [5]. More than 800,000 homes lost power, 635 roads were closed, and 88,000 homes were either damaged or destroyed as a result of the storm [5]. Robeson County, NC, has a population of 134,871, a total diabetes prevalence of 15.7%, and a demographic breakdown of 37.6% Native American, 26.6% White, and 24% Black [6]. According to the North Carolina Rural Center on Health Rankings and Living Wage, Robeson County ranks last out of all counties in North Carolina in terms of health outcomes and falls in the lowest quartile of all counties in terms of weighted average household income [7].

Although many barriers to care for individuals with diabetes have been identified in many landmark studies, the impact Hurricane Matthew and Hurricane Florence have made on diabetes self-management practices and outcomes in Robeson County, North Carolina is not fully understood [8]. To address this gap, this study was designed to understand this impact on individuals with diabetes and relevant outcomes.

Methods

Mixed methods, composed of focus groups, key informant interviews, and electronic health record (EHR) data analysis, were used to understand the impact of Hurricane Matthew diabetes self-management and outcomes shown in **Figure 1**.

Focus Groups

Focus Group Procedure

Recruitment took place from several locations (Southeastern Regional Medical Center, Southeastern Health Diabetes Clinic, Robeson County Church and Community Center, First Baptist Church off Walnut Street, and First Baptist Church off West 2nd Street) all around Lumberton, NC. Recruitment flyers for participants were left in all lobby areas, and local representatives at faith-based organizations and community centers were asked to mention the study during their services with a recruitment script. Individuals that did not have diabetes, did not live in Robeson County during Hurricane Matthew, were not over the age of 18 at the start of the study, were unable to read and write in the English language, and were involuntarily detained or incarcerated during the study were excluded from participation in the focus groups. The selection process was equitable among all relevant demographic groups as the flyers were passed out at public spaces accessible to everyone in the target population.

Participants that arrived at the focus group locations (First Baptist Church on Walnut Street or First Baptist Church on W 2nd Street) signed the consent form and completed the Emergency Preparedness Questionnaire (EPQ), a questionnaire aimed at understanding the individual level preparedness for Hurricane Matthew, including an assessment of barriers to care. This was measured with a Likert scale and values were given a numerical value. The questionnaire also was designed to see if experiencing Hurricane Matthew (2016) influenced preparation for Hurricane Florence (2018), as well as collect relevant demographic information. Focus groups were then audio recorded and a semi-structured focus group guide was utilized for each focus group session to understand the impacts of both Hurricane Matthew and Hurricane Florence on perceived access to food, medications, and supplies.

Analysis

Standard transcription methods were used to transcribe each focus group from their audio files into word documents. Documents were then analyzed using standard qualitative analysis. Focus group transcriptions were broken down into individual statements and major themes were. Each quote falling into main themes were then further labeled into subthemes and compiled into a qualitative table. A second study staff member repeated this process for accuracy purposes, and results were compared.

Key Informant Interviews

Key Informant Interview Procedure

Key informant interviews took place with the goal of understanding the healthcare provider and community leader perspective around perceived impacts on those with diabetes during Hurricane Matthew and Florence. Consent forms were signed and the interviews followed standard methodology.

Questions asked about specific experiences with health-related barriers for individuals with diabetes during both Hurricane Matthew and Hurricane Florence.

Individuals were asked to participate if they lived in Robeson County during Hurricane Matthew and were an active healthcare provider for individuals with diabetes or were in a leadership role in the community. Members of the Southeastern Health system made recommendations about whom to contact for participation in an interview. Only those over the age of 18 at the start of the study were contacted for participation in the key informant interviews.

Analysis

Interview sessions were reviewed for common themes. Themes were extracted using standard qualitative analysis techniques, and subthemes were then identified from theme-labeled quotes before compilation into a qualitative table.

Electronic Health Records

A one-year time span around Hurricane Matthew, 6 months before through 6 months after, was split into two cross sectional panels (6 months before the storm up until Hurricane Matthew and Hurricane Matthew through 6 months after the storm). Only residents of Robeson County that were over the age of 18, who were not pregnant when measured, were included in the data collection and further statistical analysis. The guidelines for what is considered diabetes, according to the American Diabetes Association, is an HbA1c level above 6.5, so all participants with an HbA1c less than 6.5 were excluded from the comparisons [9].

Analysis

To analyze changes in clinical outcomes for those with diabetes, both mean HbA1c and frequency of diabetic ketoacidosis (DKA) were compared between the two cross sectional panels. Student t-tests analyzed whether statistically significant changes in prevalent cases of DKA related ER visits and mean HbA1C changes occurred from before to after Hurricane Matthew.

Results

Focus Groups

The first focus group took place at the First Baptist Church off of West 2nd Street in Lumberton, NC. The second focus group was intended to take place at the Southeastern Regional Medical Center. This focus group had 5 participants scheduled to participate in the focus group, but only one individual was able to attend this group due to transportation-related barriers. Their responses were treated as a key informant interview. The third focus group took place at the First Baptist Church off Walnut Street.

There were observable differences in self-reported racial demographics between the first (North Lumberton) and third (South Lumberton) focus groups. The first group had primarily Black or African American identifying individuals and the third group had primarily white identifying individuals. Further data analysis shed light on differences in emergency kit preparedness for Hurricane Matthew and Hurricane Florence. No significant differences were found between Hurricane Matthew and Hurricane Florence for barriers to resources.

Note, the North Lumberton focus group had a lower sample size (n=5) when compared to the South Lumberton group (n=19), and the North Lumberton group was composed of members of the same immediate family. A lack of racial diversity was found in both focus groups and saturation among focus group responses was quickly reached. According to individuals in both focus groups,

those in the lower lying areas and near the Lumber River, often those in lower socioeconomic position (SEP), fared the worst from the impacts of the hurricane. The qualitative data represented in **Table 1** and **Table 2** highlights a lack of access to diabetes-friendly food, medications, and supplies for individuals with diabetes during both Hurricane Matthew and Hurricane Florence.

Key Informant Interviews

There were 3 registered nurses (across the Southeastern Health system), one professor from UNC- Pembroke, and one community leader that were interviewed. One of the registered nurses stated that they themselves has diabetes and that gave them an even deeper appreciation for barriers to resources needed for those with diabetes during both Hurricane Matthew and Hurricane Florence.

Health Records Data

From EHR analysis from the Southeastern Regional Medical Center, demographic characteristics from the two cross sectional panels are shown in **Table 3**.

The two cross sectional panel analysis shown in **Table 4** depicts changes in mean HbA1c from before hurricane Matthew to after, and it shows the change in frequency of diabetic ketoacidosis (DKA). Only those with an HbA1c measurement above 6.5 (per the American Diabetes Association guidelines for what is defined as someone having diabetes) were included in the comparison [9]. Confounding variables were considered; however, age, race, and sex distributions from before to after Hurricane Matthew were very similar, and thus were ignored from calculations.

Discussion

Stress and the role PTSD in the impacts on Hurricane Florence Preparation

Many different key informants brought up the idea that the hormonal response within the body of an individual that experiences a traumatic experience may develop long-term physiological problems. Furthermore, it's been hypothesized that the reason for panicking prior to Hurricane Florence was in part because of the experiences with Hurricane Matthew. Another study looking into the effects of stressors on low socioeconomic position individuals that experienced Hurricane Katrina found that increased hurricane-related stressors and loss led to worse health outcomes [11]. Further studies would have to be conducted in North Carolina before any conclusions could be drawn with Hurricane Matthew in Robeson County, but something worth considering for future studies. If this is the case that Hurricane Matthew-related stressors led to worse health outcomes, more services, especially mental health services, should be provided to those individuals that were exposed to Hurricane Matthew.

Differences in Impacts between Hurricane Matthew and Hurricane Florence

Many registered nurses noted that although the damaging results from Matthew were often worse than Hurricane Florence, the amount of resources and supplies available to take care of those individuals was much larger than for Hurricane Florence. In part, informants argue that as a result of the experiences from Hurricane Matthew, people were better able to prepare for Hurricane Florence and plan ahead of time with resources like water and medications. In addition, community members came together with the National Guard to better protect the water treatment center in downtown Lumberton, NC, from flooding, like what happened with Hurricane Matthew.

Is the American Red Cross Helpful or Antagonistic?

Each key informant interview seemed to have a perspective about the American Red Cross. Often times, it was not a positive one. One informant even described

the organization as "largely ineffective." It was further described that many rules and regulations around the shelters that they set up seem to be the cause of this frustration. As an example, one key informant detailed the struggle that many parents in emergency shelters had with the supply of diapers during the storm. Community members heard about these hardships and planned to bring large shipments of diapers to these shelters to those in need, only to be faced with rejection from American Red Cross employees because of company policy. Another informant detailed a similar situation, but with food, saying that those with diabetes had to get a special pass to have a sugary drink at their bed. It was described that this led to tensions between the American Red Cross workers and community members. The tension also caused the creation of smuggling routes to bring supplies in Red Cross emergency shelters for those that needed the supplies, a paradoxical picture to imagine.

Accessibility

Participants in focus groups had difficulty accessing the hospital due to transportation related barriers. It was described that individuals wanted to take part in the study and describe their experiences, but they could not physically get a ride to the hospital. Questions started to be raised about how an individual with diabetes would get to the hospital during a hurricane when they couldn't get to the hospital when there was not a hurricane present.

Future Interventions to limit health outcomes

Among multiple providers and leaders in the community, it has been noted that diabetes education, catered specifically for those with diabetes and what to pack in preparation for the storm, would be incredibly helpful. The possibility of providing this education to those that are "bored" in emergency shelters would offer a great setting to reach many individuals that could benefit from this education, while others have argued that individuals may still be in shock from having just lost everything and not able to find education useful. Another

suggestion has been noted to make a list that can be easily and widely distributed to individuals with diabetes that has a list of all necessary supplies in an emergency supply kit that is catered to their needs. This gets at the idea of precision medicine and the importance of catering interventions and education to the individual patient.

Limitations

Individuals with diabetes during the focus group often had difficulty distinguishing the difference between experiences with Hurricane Matthew and Hurricane Florence leading to possible recall bias. Although time was given between discussions of the hurricanes for participants to orient themselves around when each storm hit the area and experiences they had with each, some participants exclaimed this frustration of differentiation. Furthermore, focus groups lacked racial diversity (compared with racial diversity seen in EHR analysis and other literature sources) and one focus group even had only members of the same immediate family.

The key informant interview data collect relies on the opinions and experiences of a select and limited number of leaders identified as representing the community of Robeson County, NC. However, it is possible that the results would have been different if a different set of key informants had been selected to interview. Further, several individuals that were invited to participate were not able to join for a variety of reasons. Results from this data should be interpreted with other Lumberton County data. Furthermore, qualitative data is often difficult to generate consistent analysis, and is often up to interpretation by the analyzer of what quotes and themes are representative of the views of the entire group of individuals. Although two individuals were reviewing qualitative themes, more individuals to review qualitative data may have produced more representative themes.

Despite focus groups and key informants reaching saturation, defined as no additional data are being found on a specific topic so that characteristics of a certain variable can be described, generalization to all groups in the population would not be appropriate, as some groups were not well represented at focus groups or reached with key informant interviews [12].

The cross-sectional panels approach to understanding clinical characteristics of those with diabetes after Hurricane Matthew has limitations because the same individuals were not followed over time. Secondly, HbA1c measurements could have been taken right after Hurricane Matthew (within a few weeks after) and fall into the after cross-section, but not represent the impact of the storm since most of the 3 month average is being impacted by the glycemic stress before the hurricane.

Conclusions

Robeson County is a poor county with many individuals facing barriers when accessing proper healthcare without a hurricane present, let alone when a Category 5 hurricane forces thousands to evacuate. The perceived access to diabetes-specific food, medications, and supplies were limited for individuals with diabetes during both Hurricane Matthew and Hurricane Florence. Emergency shelters currently do not appear to provide adequate accommodations for individuals with diabetes to appropriately manage their condition, and future interventions should improve resources available in emergency shelters catered for those with diabetes including healthful foods, diabetes medications, and useful supplies. Additional tools should be provided to those with diabetes so that they are fully aware what resources they should prepare ahead of a natural disaster. This emergency preparedness kit should have information about what medications they currently have prescriptions for and what dosages are appropriate. This is a critical resource for healthcare

providers in emergency shelters to know which medication and how much of it to give.

From focus group discussions and key informant experiences, Hurricane Matthew made long-term impacts on those with diabetes and influenced the way they prepared for Hurricane Florence. There were not statistically significant results from the barriers to care assessment that were observed in the Emergency Preparedness Questionnaire.

From EHR data analysis from the Southeastern Regional Medical Center, mean HbA1c did not significantly change from the 6 month prior to Hurricane Matthew cross-sectional panel when compared with the 6 month after Hurricane Matthew cross-sectional panel. However, the frequency of DKA did significantly increase from before Hurricane Matthew to after when comparing their respective cross sectional panels. Because HbA1c is a three month average, it makes sense that Hurricane Matthew may not have significantly changed an individuals HbA1c value depending on when measurements were taken. On the other hand, DKA is a diabetic emergency that can occur more rapidly with poorly managed blood glucose levels. Policy change has been identified as a useful way to increase access to the tools and resources that individuals with diabetes need to adequately manage their diabetes. Policy change should focus on increasing access to food, medications, and supplies for those with diabetes in emergency shelters.

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Table 1. Theme extractions from 2 focus groups of individuals with diabetes; one group from South Lumberton (n=20) and one group from North Lumberton (n=5).

Theme	Sub-theme	Text
Food	Power	"My power went out for about 7 days, so we ended up cooking everything we had in the freezer, but some of the churches had hot meals…"
		"We couldn't cook a lot of things without power. They weren't in the shelters during Florence"
	Diabetes Management	"Accessing a balanced diet was hard. We didn't have access to food. Our stores were shut down."
		"And with diabetes, the kind of food you have to eat- it's hard to get it"
		"Everybody had to change [their diet]. You ate all your reserves, ate out of a can, and when you went to the store, everything was gone or very expensive."
	Emergency Shelters	"The Red Cross- they don't care about us. The food doesn't benefit us."
	Community	"There were [many] going through this and they worked together… to get food and we all went together."
	Flooding	"But each time we had to evacuate, we had to go and stay with one of our children and they were fast food eaters."
Medications	Emergency Shelters	"CVS came down [to the shelter] to fill the prescriptions. One [time] in eight days."
		"As far as it goes for my doctor, I can just reach out. Like I can just use my phone to email my pharmacist to get it sent in, but if I'm at the shelter without my phone, somebody needs to be able to go and get it…"
	Community	"I guess you could get your medicine before, like if you see it on the radio, TV, or news, you can go and get everything you need."
		"If the pharmacy or drug store was closed, you couldn't get [your medications]. Many of them were robbed to get the medicines."
	Flooding	"Those shelters need to be able to have the medications for you. In case the storm hit [and] you didn't pack your insulin, they need to be able to have that insulin for you."
		"I was out of my medication and [The closest supplier] was 170 miles away."
Diabetes Supplies and Community Resources	Power	"If you didn't have a cell phone, when the power went out, there was no way to get in contact with the doctor."
	Diabetes Management	"There were a lot of changes you have to go through [when evacuating]. And we couldn't carry it all with us because carrying all that I have to medically… the old oxygen thing with us was a big inconvenience."
		I think it was harder for everyone. It was something new to us. When Florence came along, at least we had some idea of what to do. But when Matthew came, we were in the dark about everything."
		"[Diabetes education] would've helped during this time."
		"…it didn't take but three days, but I was out of my test strips [then]."
	Emergency Shelters	"Yeah just having someone to check your blood pressure and blood sugar [at the emergency shelters] is needed. Like if you get sick, who does that?"
	Community	"During Hurricane Matthew, they seemed more readily available for us to fill out the FEMA application. My situation is a little different… I'm still out of my home."
		"Gas prices went sky high. Prices everywhere."
		"Yeah, you can see the difference [in FEMA funding] because if you drive down to the Tanglewood area (North Lumberton), you can see all the sides being torn out and being repaired, but down this way (South Lumberton), nothing."
		"5th street did better off with funding, they had more funding. In regards to FEMA, they would turn

		people away from the other parts of town saying, 'sorry, your area wasn't affected.'"
	Flooding	"No transportation to [the doctor's office]. Roads were closed and you couldn't get to it… they weren't open anyways."
		"First time that we had water in this area, I saw the water; it was coming down the street. So, the emergency vehicles… they ain't coming down."

Table 2. Theme extractions from 5 key informant interviews of leaders in the community; Individuals are representing their experiences caring for individuals with diabetes during either Hurricane Matthew or Hurricane Florence (n=5).

Theme	Sub-theme	Text	Informant
Infrastructure changes	Food Access	"In this county, people don't really have access to steak or chicken or stuff like that."	RN
		"People came into the ER and they didn't have [food]. I would give out boxed lunches, which was a sandwich and some apple sauce."	RN
		" I was looking for them to have a good source of complex carbohydrates such as fresh fruits and vegetables, which we did not have access to at all during Hurricane Matthew."	RN and Professor
		"We have a program in the school system that will pack a bag lunch for a kid over the weekend. I mean if a kid can't eat over the weekend, what will they do over 5 days?"	RN
	Community	"[For Hurricane Florence] they brought along people from other organizations. The Cajun Army were here for four or five days… you didn't see that during Hurricane Matthew."	RN
	Disparities	"Definitely [some] areas were hit harder. I mean MLK [was hit] so bad and well no one can afford to be flooded, but that area definitely couldn't afford [it]."	RN
		"Jim Crow segregation: [Certain] populations around the county… have been pushed to the less desirable, low lying areas of the county and were more affected by the storm."	RN
	Utilities	"Yeah I think most people would agree that water is more important than electricity because you can't take a shower, you can't flush your toilet…"	RN
		"There was a large tower carrying lots of power lines in a low-lying swamp that collapsed. The power was out for everywhere and it was nearly a week before they got it back up."	Community Center Leader
		"Most of the grocery stores were closed due to the lack of power."	Community Center Leader
	Flooding	"[For Matthew] the river was rising in South and West Lumberton, people were pulled from their houses by helicopter and boat."	Community Center Leader
Clinical Access and Resources	Medications	"[When those with a chronic disease] don't get their meds, [they] go through withdrawals."	RN
		"No, I don't think people packed emergency kits. I worked in the ER and people were coming in and wanted their HIV medicines, insulin was a big one, and Lasix for heart patients. Another is oxygen, people came in to [use] our oxygen because they didn't have it at home."	RN
		"It's tough for shelters to dispense medications because they aren't a pharmacy…"	RN
		"Most of our folks who were flooded may not have had access to their insulin for weeks."	RN
		"It's hard for someone who lives day to day to prepare. They may be buying medications a week at a time [and] may not have insurance. They had trouble with transportation."	RN
Clinical Access and Resources	Medications	"We had several patients that their only way out is to go to the emergency room because they are in DKA and the only way to get medications would be to go to the emergency room."	RN
		"I can't imagine being a mother and your child just came out of DKA and [now you] are wondering how they are going to get their medications or keep them cool. The insulin analogs will stay viable up to 28 days, [but] knowledge about that… is key."	RN
		"I couldn't help you if you didn't know the name of your medications. Many of them came with no medications [and] often they didn't know the name or dosage of the medications."	RN
		"When you just refilled your prescription last week, so you can't refill your prescription for another month, but it just went bad, that's when you have to evacuate your home."	Community Center Leader
	Disparities	"Now for Florence, those who have wealth were more prepared and able to go out and spend some of that money that was socked away for a rainy day."	Community Center Leader

		"Folks who had 400% below federal poverty guideline were the ones that got it so bad [with Matthew]. The folks tended to be uninsured, so they don't necessarily have access to medications all the time, not just during a natural disaster."	RN
		"Medical care was hindered for the entire population, [but] more critical for those with symptoms related to kidney and renal diseases because healthcare was non-existent during Hurricane Matthew. The hospital wasn't open. For Florence, most clinics were closed."	RN and Professor
Clinical Access and Resources	Food Access	"Patients were on a specific dietary regimen and doing well, and then boom, they would eat whatever they could eat and then complain about their high [blood sugar] numbers." Food access RN	RN
Emergency Shelters	Medications	"[Shelters provided] food, water, and things like that, but medications and supplies… no."	RN
	Community	"Matthew, we staffed shelters. Florence was not as bad, structurally, for many of the clinics."	RN
		"Shelters were set up [in precaution], and staff thought they would only need them for very few days. We did not think Hurricane Matthew [would] actually impact our area much."	RN and Professor
		"The purpose of the shelters isn't to provide medical services. The way they're putting [them] up, according to the law, they're doing a good job. I think the law is inadequate."	RN and Professor
		"I strongly disagree [that emergency shelters provided adequate resources]. I think [the emergency shelters] did a terrible job. In my opinion they did not provide adequate resources."	RN and Professor
	Flooding	"Matthew affected more people and put more people out of their homes and into shelters."	RN
	Food Access	"[Shelters] tend to have one simple menu that does not address the needs of the diabetic. I think we need to stop and have a different type of program for those populations."	RN and Professor

Table 3. Demographic clinical data from Southeastern Regional Medical Center EHR data.		
	6 months BEFORE Hurricane Matthew (n=3,057)	**6 months AFTER Hurricane Matthew (n=2,940)**
Mean Age (years)		
	64	64
Sex		
Male	1,342 (43.9%)	1,288 (42.0%)
Female	1,715 (56.1%)	1,651 (57.8%)
Race		
White	1,060 (34.7%)	971 (34.3%)
Black or African American	703 (23.0%)	716 (21.7%)
American Indian or Alaska Native	579 (18.9%)	608 (21.4%)
Asian	116 (3.8%)	110 (3.2%)
Native Hawaiian or Other Pacific Islander	1 (<1%)	1 (<1%)
Hispanic	3 (<1%)	4 (<1%)
Other	595 (19.5%)	530 (19.1%)

Table 4. HbA1c and frequency of DKA from Electronic Health Record (EHR) data from the Southeastern Regional Medical Center pulled from before and after Hurricane Matthew.

Time Period	Mean HbA1c (SD)*	Frequency of DKA (%)
Within 6 months before the storm (n=3,057)	8.34 (1.87)	39 cases out of 4,025 admissions (1.0%)
Within 6 months after the storm (n= 2,940)	8.31 (1.93)	87 cases out of 3,779 admissions (2.3%)
Independent T-test (p-value)	0.54	< 0.0001
* If an individual had more than HbA1c measure, the data point that was further away, based on date, from the storm landfall in North Carolina (October 8th, 2016) was chosen. ** Significant p value calculated		

Figure notes: Figure 1 is attached to submission. Please include following figure description:

Figure 1. Overview of approach to understand the impact Hurricane Matthew had on individuals with diabetes. Three main approaches (2 qualitative and 1 quantitative) were explored in mixed methods paradigm.

Concluding Thoughts

Individuals with diabetes in Robeson County, NC, experienced a lack of access to vital resources, including food, water, medications, and supplies, during Hurricane Matthew and Hurricane Florence. The irony of the situation how focus groups were scheduled weeks in advance to discuss the impacts of Hurricane Matthew in the fall of 2018 and they had to be rescheduled because Hurricane Florence hit the same area during those days emphasizes the desperate need for a change in infrastructure, policy, and access to these vital resources for this population. From focus groups, access to these diabetes resources are reduced directly by infrastructure (road and clinical closures) as well as utility changes (power and water shortages). Key informant interviews shed light on some disparities that are perpetuated by the presence of a hurricane. Individuals describe the fact that those who have been historically pushed to the lower (topographically), less desirable parts of town and are impacted by more floods. Secondly, key informants identify the problem that many individuals with diabetes that struggle with access to diabetes food, medications, and supplies without a hurricane present go through an even more challenging process attempting to obtain these resources during a natural disaster. Electronic Health Record analysis from the Southeastern Regional Medical Center shows that long-term blood glucose measurements (over a 3 month average) did not significantly change as a result of Hurricane Matthew. The frequency of diabetes emergencies, on the other hand, did significantly increase after the storm, shedding light on the idea that Hurricane Matthew impacted individual's abilities to effectively manage their diabetes in the short term (day to day). More research should investigate how these clinical outcomes changed from before to after Hurricane Florence. In addition, work on the societal level should be completed by policy makers to ensure access to these critical supplies are present for individuals with diabetes and other chronic diseases during a hurricane.

For the second focus group that was held, only one individual was able to attend and participate in the group discussion. Despite significant efforts made to bring interested individuals with diabetes to the hospital where the focus group was being held (using Uber or Lyft as resources to get them there), no success was found. Uber and Lyft drivers in the area could not be located and it was around 5 PM on a Thursday. It is interesting to think about how these individuals would get to the hospital if they had an emergency when they weren't able to get there for the focus group. Furthermore, during a natural disaster like Hurricane Matthew, the problems with travel-related barriers are compounded for these individuals by the flooding waters that made travel near impossible.

It is important to note that some of the focus group responses differed based on the experiences of those living North of the Lumber River compared to those South of the Lumber River. Most notably, focus group participants from the North Lumberton group discussed more impacts to their area in terms of flooding and lack of access to resources from Hurricane Florence compared with Hurricane Matthew. This was the opposite for participants from the South Lumberton group. In order to address these differences in impacts, further studies should hold focus groups that solely discuss one hurricane at a time closer to the time of the storm.

Table 5. Focus Group demographic data self-reported from the Emergency Preparedness Questionnaire (EPQ) stratified with location of focus group.			
Clinical Characteristics	South Lumberton (n=19)	North Lumberton (n=5)	Total (n=24) *
Sex			
Male	10 (52.6%)	2 (40.0%)	12 (50.0%)
Female	8 (42.1%)	3 (60.0%)	11 (45.8%)
Other	1 (5.3%)	0 (0.0%)	1 (4.2%)
Race*			
White	0 (0.0%)	5 (100.0%)	5 (20.8%)
Black or African American	18 (94.7%)	0 (0.0%)	18 (75.0%)

American Indian or Alaska Native	2 (10.5%)	0 (0.0%)	2 (8.3%)
* Individuals could identify with more than one race.			

This will also help with the problem of recall bias in distinguishing what events happened with which hurricane for focus group participants in this study. To further assist with recall bias, focus group data should be collected within a reasonable amount of time after the storm has passed and recent enough (more recent than 2 years after) that memories are as clear as possible. Next, more focus groups held around different parts of town will allow for more demographic groups to be included in the qualitative data, adding to the generalizability of the study. Clinical data self-reported by focus group participants from the Emergency Preparedness Questionnaire is shown in the table below.

Table 6. Focus Group clinical data self-reported from the EPQ stratified with location of focus group. *			
Clinical Characteristics	**South Lumberton: Focus Group 1 (n=19) ****	**North Lumberton: Focus Group 2 (n=5) ****	**Total (n=24) ****
Mean BMI (SD)	32.54 (6.0)	27.36 (7.3)	31.46 (6.5)
Type 1 Diabetes (%)	3 (15.8%)	1 (20%)	4 (16.7%)
Type 2 Diabetes (%)	13 (68.4%)	2 (40%)	15 (62.5%)
Type of Diabetes: Unknown or Blank	3 (15.8%)	2 (40%)	5 (20.8%)
Frequency of DKA (%)	2 (10.5%)	0 (0%)	2 (8.3%)
Had Emergency Kit for Hurricane Matthew (%)	10 (52.6%)	4 (80%)	14 (58.3%)
Had Emergency Kit for Hurricane Florence (%)	13 (68.4%)	4 (80%)	17 (70.8%)
* Location of Lumberton is relative to the Lumber River that cuts the city of Lumberton in two parts			
** n varies slightly due to occasional missing data			

The idea that Hurricane Matthew impacted the way individuals with diabetes prepared for Hurricane Florence (or future storms) was explored. Individual responses on the Emergency Preparedness Questionnaire regarding access to resources and the impact of the hurricanes were scored using a Likert scale and numerically valued in the table below. No statistical differences in access to

resources or impacts of the hurricanes were observed from this data, but further measurements and studies exploring how Hurricane Matthew may have impacted preparedness for Hurricane Florence should be explored.

Table 7. Barriers to care from the Emergency Preparedness Questionnaire (EPQ) for both focus groups (n=24). All p values comparing Hurricane Matthew and Hurricane Florence responses NS.

Barriers to Resources	Assessment Questions	Mean "Barrier" Response (SD)*
In regards to Hurricane Matthew…		
Access to food	*"I was not able to get enough food or drink."*	1.91 (1.8)
Access to medications	*"I was not able to get diabetes medications and supplies."*	2.05 (2.2)
Impact of the hurricane	*"Controlling my diabetes was challenging."*	0.91 (1.1)
In regards to Hurricane Florence…		
Access to food	*"I was not able to get enough food or drink."*	1.70 (1.7)
Access to medications	*"I was not able to get diabetes medications and supplies."*	2.05 (2.0)
Impact of the hurricane	*"Controlling my diabetes was challenging."*	1.09 (1.3)

* Barrier responses were given a numerical score *(Never=0; Rarely=1; Sometimes=2; Often=3; Usually=4; Always=5)*.

Many focus group participants brought up disparities in access to FEMA funding from those that lived in south of or near the Lumber River compared with those that lived farther north of the river in higher elevations. In order to further explore some of these findings, future studies should examine specifically which communities are receiving funding from FEMA relative to which areas sustained damages. This would identify areas that are being impacted by hurricanes, but are not receiving the funding they need to rebuild their communities before another catastrophic storm hits the same area.

Key informants that were targeted for an interview in this study were individuals identified by a select group of healthcare providers. More community members, school workers, public servants, hospital employees, physicians, and religious leaders should be asked about their experiences with hurricanes in Robeson County, NC, and their experiences on how those with diabetes were impacted by the storms. This would provide a better understanding regarding the impacts of a hurricane on all members of the population, not just those that were connected to the Southeastern Health system or the local community center.

Electronic health data analysis around Hurricane Matthew would be improved if data could be correctly filtered with ICD-10 codes, such that only those with diabetes are included in the study parameters. In addition, a further study utilizing a longitudinal format regarding tracking the same individuals before and after Hurricane Matthew would provide results with fewer limitations around sample size and unknown participant changes from the first cross sectional panel to the second observed in this study.

Robeson County, NC, is a rural county that struggles with access to resources without a hurricane present; when a category 5 hurricane wipes out roads and businesses, those that can't access resources normally won't have any chance at getting the food, water, medications, and supplies they need. This community also has many individuals with uncontrolled diabetes. From a 2006 study, the US and England have mean HbA1c values of 7.5% and 7.6%, respectively [33]. Comparing those values to the mean HbA1c values measured in this study before and after Hurricane Matthew to be 8.34 and 8.31, respectively. This shows a lack of glycemic control in Robeson County, and compounds the problems that are seen when an individual with diabetes tries to manage their diabetes when a major disaster hits.

From both focus group data and key informant data, it became clear that perceived benefits from the American Red Cross are not as great as they can

be. Many individuals described instances where outside donations like baby diapers were brought for use by those living in emergency shelters only to be turned away by American Red Cross employees. It was explained that this is as a result of company policy. It would be interesting for future studies to examine more about this by hearing from the American Red Cross, and specifically ask questions about why this policy is in place. Other resources like FEMA also drew interesting comments regarding disparities in who has access to funds. It was described that some would go and seek financial support from FEMA with major home damages from the storm, and due to the geographic location of their home, they were denied funding. It was further explained that certain areas of Lumberton were defined as being the areas that were most impacted by the storm, and others were not. Focus group participants exclaimed that a hurricane does not follow strict lines drawn on a map, and thus, they wanted more equitable FEMA support. Future studies should investigate more about FEMA and what qualifies someone to receive this funding during a natural disaster in Robeson County versus one who would not.

Further studies should investigate the impacts of having diabetes-friendly food, medications and supplies in emergency shelters for those with diabetes. This would involve providing these resources to the emergency shelters, if they allow them, and see if there are significant improvements in perceived access to resources and diabetes outcomes for this population. Other interventions like having more diabetes educators and healthcare providers available to those that evacuate to an emergency shelter should be tested for efficacy of preventing worsening diabetes outcomes. These educators could provide helpful tips to those that are waiting in the emergency shelters. A more comprehensive understanding around knowledge of what to pack in an emergency kit should also be explored. This type of study should see if individuals with diabetes in Robeson County, NC, know what kinds or the amounts of supplies and resources they need for a storm lasting as long as Hurricane Matthew. If it turns out that individuals are not fully aware of these items, a tool should be created

that can be mass distributed for individuals with diabetes living in Robeson County that is targeted towards their population (literacy level, relevant resources, and ways to seek help).

The incredible support and community in Lumberton, NC, made this research project possible. It became apparent early on that despite this area going through a rough turn of events (one of the hardest hit counties by Hurricane Matthew only to get flooded by Hurricane Florence two years later), those that live in Lumberton, NC, those in Robeson County, especially those with diabetes, continually trust and lean on those around them to get through the highs and the lows of a natural disaster. This was evident in the incredible support from religious organizations passing out canned foods and the fire departments distributing bottled water whenever possible.

Appendix

Emergency Preparedness Questionnaire

The following questions will ask about your experiences with Hurricane Matthew and Hurricane Florence and help distinguish any differences in preparation for the storms.

1. Today's date is:

   Month   Day   Year

2. Your birthdate is:

   Month   Day   Year

3. What is your gender?

   _____Female   _____Male   _____Other

4. What is your race? **(Mark Yes or No for each)**

Yes	No	Race
❑	❑	African American
❑	❑	American Indian
❑	❑	Hispanic
❑	❑	White
❑	❑	Other

5. What is your height and weight?

   Height (ft., in.)   Weight (lbs.)

6. When did a doctor or a nurse first tell you that you had diabetes? This means when you were told about your diabetes diagnosis.

   Month   Year

7. A test for hemoglobin A1C ("A one C") measures the average level of blood sugar over the past three months. What was your most recent hemoglobin A1C?

   ☐ . ☐ (Write in number)   ❑ I don't know

8. In the time frame of 2016 to 2018, were you hospitalized for diabetic ketoacidosis (DKA)?

    ❑ Yes   ❑ No   ❑ I don't know

9. What level of education have you completed?
    ❑ I have not completed High School   ❑ High School Graduate/GED
    ❑ Some College   ❑ College Graduate
    ❑ Masters Degree   ❑ Doctorate Degree

10. Which of the following describes you?

    ❑   ❑   ❑
    I have Type 1 diabetes   I have Type 2 diabetes   I am not sure what diabetes I have

11. How do you take insulin? **Check all that apply**.

    ❑   With a syringe (needle)
    ❑   With an insulin pen
    ❑   With an insulin pump
    ❑   I use oral medications
    ❑   I use non-insulin injectables
    ❑   I do not use any of the options
    ❑   I am not sure what I use

12. Have you ever been asked to take insulin by your healthcare provider?
    ❑ Yes and I take insulin

    ❑ Yes and I don't take insulin because:
        ❑ Cost
        ❑ No insurance
        ❑ Instructed to stop taking
        ❑ Other:
        _____
    ❑ No

13. Mark the following natural disasters that you have experienced? **Mark all that apply.**

    ❑   ❑   ❑   ❑   ❑
    Hurricane   Tornado   Flood   Winter Storm   Fire

14. How many natural disasters have you faced in your lifetime? (Any of the above mentioned)

❏   ❏   ❏
None   One   Two or more

15. Did you live in an area that was affected by Hurricane Matthew or Hurricane Florence?

❏   ❏
Yes   No

16. Did you have an emergency supply kit prior to Hurricane Matthew?

❏   ❏
Yes   No

17. If yes to the previous question, did your emergency supply kit include the following items:

	Yes	No
A minimum three (3) day supply of food and water?	❏	❏
A minimum three (3) day supply of diabetes medication and supplies?	❏	❏
Copies of Insurance or Medicare card?	❏	❏
Glucose tablets, soda with sugar, juice and hard candies?	❏	❏
Log book of blood sugars?	❏	❏
Unexpired glucagon emergency kit?	❏	❏
Contact list (including family doctor, emergency help line number, family members, etc.)?	❏	❏
Other: _____		

18. Did you have an emergency supply kit prior to Hurricane Florence?

❏   ❏
Yes   No

19. If yes to the previous question, did your emergency supply kit include the following items:

	Yes	No
A minimum three (3) day supply of food and water?	❏	❏
A minimum three (3) day supply of diabetes medication and supplies?	❏	❏

Copies of Insurance or Medicare card?	❏	❏
Glucose tablets, soda with sugar, juice and hard candies?	❏	❏
Log book of blood sugars?	❏	❏
Unexpired glucagon emergency kit?	❏	❏
Contact list (including family doctor, emergency help line number, family members, etc.)?	❏	❏

Other: _____

The following statements are about your experiences during Hurricane Matthew. Please think about your experiences during Hurricane Matthew:

	Never	Rarely	Sometimes	Often	Usually	Always
20. I was not able to get enough food or drink.	❏	❏	❏	❏	❏	❏
21. I was not able to get diabetes medication and supplies.	❏	❏	❏	❏	❏	❏
22. Controlling my diabetes was challenging.	❏	❏	❏	❏	❏	❏
23. I checked my blood sugar on a daily basis.	❏	❏	❏	❏	❏	❏

The following statements are about your experiences during Hurricane Florence. Please think about your experiences during Hurricane Florence:

	Never	Rarely	Sometimes	Often	Usually	Always
24. I was not able to obtain adequate amount of food or drink.	❏	❏	❏	❏	❏	❏
25. I was not able to obtain diabetes medication and supplies.	❏	❏	❏	❏	❏	❏
26. Controlling my diabetes was challenging.	❏	❏	❏	❏	❏	❏

27. I checked my
blood sugar on a   ❑   ❑   ❑   ❑   ❑   ❑
daily basis.

28. Are there any additional comments you think would be important for us to
know about your experiences with Hurricane Matthew or Hurricane
Florence?

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Focus Group Guide

Introduction:
      a. Thank you for coming.
      b. Your presence is important; you are representing many individuals with diabetes that will benefit from this research.
      c. Explain and review Informed Consent/ Confidentiality Focus Group document.
          Describe what a focus group is-to learn about your beliefs and viewpoints

The following questions will ask about your experiences with Hurricane Matthew and Hurricane Florence. Please clarify any differences in your preparation for the storms.

I'm going to start with questions about the recent storm, Hurricane Florence.

1. How did Hurricane Florence affect your diabetes self-management?
Probes:
      a. What were the barriers to controlling your blood sugars before, during, and after Hurricane Florence?
      b. How do you define a balanced diet?
      c. Was accessing a balanced diet, including water, more difficult during Hurricane Florence?
      d. How did your diet change as a result of the storm?
      e. Describe the process of obtaining your medication or test strips during the storm?
      f. Did you pack and/or use an emergency kit to control your blood glucose? If not, why not?
      g. What difficulties did you have attending clinical appointments?

Now please take some time to think back to your experiences with Hurricane Matthew (October 2016).

2. How did Hurricane Matthew affect your diabetes self-management?
Probes:
      a. What were the barriers to controlling your blood sugars before, during, and after Hurricane Matthew?
      b. How do you define a balanced diet?
      c. Was accessing a balanced diet, including water, more difficult during Hurricane Matthew?
      d. How did your diet change as a result of the storm?

e. Describe the process of obtaining your medication or test strips during the storm?

f. Did you pack and/or use an emergency kit to control your blood glucose? If not, why not?

g. What difficulties did you have attending clinical appointments?

3. How did Hurricane Matthew influence how you prepared for Hurricane Florence?

    a. Did you feel more or less prepared for Hurricane Florence? Why?

    b. Did you pack an emergency kit for Hurricane Florence? What did you pack in your emergency kit?

    c. Were there differences in the community resources available to you?

4. In the future, what would be helpful for individuals with diabetes during a natural disaster? Probe: what resources, education, shelter things, do people need?

    a. What would be a helpful and convenient way to learn about preparing a balanced diet for a natural disaster or during it?

    b. What are some different ways doctors, nurses, or people in the community (i.e. American Red Cross) could help you manage your diabetes during a natural disaster?

    c. Would diabetes education have helped you during this time frame? If not, why not?

    d. What would make it more convenient or possible for you to get your diabetes medication(s) during a natural disaster?

5. If there is anything else you think would be important for me to know relating to how hurricanes and other natural disasters have affected you or could affect someone with diabetes, please mention it at this point.

Key Informant Interview Guide

<u>**Introduction:**</u>
Thank you for taking the time to speak with me today. My name is Kevin Travia and I am conducting research to better understand the effects of Hurricane Matthew on diabetes self-management and outcomes. People manage resource shortages by using a number of different strategies. The following questions will ask about your experiences with individuals with diabetes and the way they prepared or fared during Hurricane Matthew and Hurricane Florence. Please distinguish any differences in preparation for the storms.

This information will really help us to understand the impacts of Hurricane Matthew and Hurricane Florence on the self-management abilities of those with diabetes in Robeson County, NC.

Do you have any questions before we begin?

Okay, here is the first question:

1. **(I/We) worried whether community members with diabetes in Robeson County had access to food, water, and medications during Hurricane Florence. Do you <u>Strongly Disagree</u>, <u>Disagree</u>, <u>Neutral</u>, <u>Agree</u>, or <u>Strongly Agree</u> with the previous statement?**

PROBES:
- How do you define "access to food" and "access to water"?
- What medications were you considering when thinking about accessibility for this question?
- What kind of food did you think about when you answered this question?
- Did you think about all of the food in your house or only certain foods, like foods that you like or foods you consider to be healthy?
- Who did you consider as part of your "community" when you answered this question?

2. **In (my/our) experience, emergency shelters provided adequate resources (food, water, shelter, diabetes medications, and supplies) for community members with diabetes during the time directly after Hurricane Florence. Do you <u>Strongly Disagree</u>, <u>Disagree</u>, <u>Neutral</u>, <u>Agree</u>, or <u>Strongly Agree</u> with the previous statement?**

PROBES:
- What does "adequate resources" mean to you when thinking about individuals with diabetes?
- What are your experiences with emergency shelters and the people that run them?

Please think about Hurricane Matthew that made landfall in Robeson County on October 8th, 2016, for the following questions.

3. **(I/We) worried whether community members with diabetes in Robeson County had access to food, water, and medications during Hurricane Matthew. Do you <u>Strongly Disagree</u>, <u>Disagree</u>, <u>Neutral</u>, <u>Agree</u>, or <u>Strongly Agree</u> with the previous statement?**

PROBES:
- How do you define "access to food" and "access to water"?
- What medications were you considering when thinking about accessibility for this question?
- What kind of food did you think about when you answered this question?
- Did you think about all of the food in your house or only certain foods, like foods that you like or foods you consider to be healthy?
- Who did you consider as part of your "community" when you answered this question

4. **In (my/our) experience, emergency shelters provided adequate resources (food, water, shelter, diabetes medications, and supplies) for community members with diabetes during the time directly after Hurricane Matthew (Oct 8, 2016). Do you <u>Strongly Disagree</u>, <u>Disagree</u>, <u>Neutral</u>, <u>Agree</u>, or <u>Strongly Agree</u> with the previous statement?**

PROBES:
- What does "adequate resources" mean to you when thinking about individuals with diabetes?
- If you disagree or strongly disagree, please explain the specific ways in which resources are inadequate.
- Do you think emergency shelters were effective at providing resources such as food and water for individuals with diabetes in the community?

5. **In (my/our) opinion, Hurricane Matthew impacted the way individuals with diabetes prepared for Hurricane Florence. Do you <u>Strongly Disagree</u>, <u>Disagree</u>, <u>Neutral</u>, <u>Agree</u>, or <u>Strongly Agree</u> with the previous statement?**

PROBES:
- How do you define a "diabetes preparation?"
- Tell me more about your experiences with natural disaster preparation for individuals with diabetes.

6. **During either Hurricane Matthew or Hurricane Florence, did you find that accessing healthcare options was hindered for a specific demographic group of individuals with diabetes more than others?**

    PROBES:
    - When you answered this question, what did "hindered" mean to you?
    - If so, in what ways were healthcare options hindered?
    - Tell me a little bit more about why your experience with healthcare access and how that pertains to a specific group of people with diabetes.

7. **What other resources or programs would be helpful for individuals with diabetes during a natural disaster?**
    PROBES:
    - Did the American Red Cross or other disaster relief agencies provide a noticeable impact on the way individuals with diabetes accessed resources such as food and water during either Hurricane Matthew or Hurricane Florence?
    - Would a group class or education session provide impactful knowledge regarding emergency preparedness for individuals with diabetes? Why or why not?

8. **If there is anything else you think would be important for me to know, please mention it at this point.**

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