A Perfect Storm of Mental Health Conditions? An Empirical Study of Hurricane Irma's Impact in Florida

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Abstract

This study investigates the impact of Hurricane Irma on mental health service utilization in Florida, using detailed patient and visit-level data from all hospitals across the state. Employing a difference-in-differences approach, we examine both the immediate and longer-term effects of the hurricane on outpatient visits for the top five mental health disorders: depressive disorders, schizophrenia spectrum disorders, bipolar disorders, trauma-related disorders, and suicidal ideation. Our findings reveal a significant decrease in follow-up visits for depressive and schizophrenia spectrum disorders, indicating a disruption in continuity of care, while new visits for trauma-related disorders increased in the long term, reflecting the delayed psychological impact of the disaster. These results highlight the critical need for resilient mental health services in disaster-prone regions and provide valuable insights for policymakers and healthcare providers in enhancing disaster preparedness and response strategies.

Keywords: Hurricane Irma, Mental Health, Service Utilization, Disaster Impact

1. Introduction

As climate change accelerates, the frequency, intensity, and severity of extreme weather events—such as hurricanes, heatwaves, floods, and wildfires—are on the rise, with profound consequences for both the environment and human health (Weilnhammer et al., 2021). From 2017 to 2019 alone, there were 44 "billion-dollar disasters" in the United States, with a total cost exceeding $460 billion (National Oceanic and Atmospheric Administration [NOAA], 2020). These catastrophic events often devastate entire communities, displacing populations and destroying critical infrastructure. At the same time, financial fragility is widespread, with more than 30% of U.S. families spending over 30% of their income on housing (Joint Center for Housing Studies of Harvard University, 2019) and nearly 40% of Americans unable to cover a $400 emergency expense without borrowing or selling something (Board of Governors of the Federal Reserve System, 2020). This combination of increasing natural disasters and financial vulnerability leads to significant economic hardship, including declines in credit health, housing instability, and widening inequalities. Notably, healthcare spending, particularly on mental health services, often declines sharply post-disaster as individuals delay or forgo treatment due to financial constraints, further exacerbating the adverse effects on both physical and mental well-being (Rudowitz et al., 2006; Hunter et al., 2021).

Hurricanes rank among the most destructive natural disasters, consistently posing significant risks to coastal communities. Over the past century, Florida has experienced more than 100 major hurricanes, with climate change expected to further increase the frequency and severity of these events. The mental health consequences of hurricanes are profound, often manifesting in conditions such as post-traumatic stress disorder (PTSD), anxiety, and depression. These psychological effects are frequently compounded by the financial hardships that follow,

including property damage, income loss, and the substantial costs of recovery, which can exacerbate mental health conditions and have lasting impacts on individual well-being. The case of Hurricane Irma in 2017 exemplifies the severe impact of such storms. As Irma approached Florida as a Category 5 hurricane, evacuation orders were issued for 6.5 million residents, while extensive media coverage underscored the threat posed to densely populated areas. The storm inflicted over $50 billion in damages, making it one of the costliest hurricanes in U.S. history. The psychological toll was significant, as the stress and anxiety associated with evacuation, property loss, and financial uncertainty had enduring effects on the affected populations (Farrell & Greig, 2018).

Existing research on climate change and extreme weather events has predominantly focused on the immediate physical health impacts and the disruption of general healthcare services, with limited attention given to the mental health consequences of such disasters. The mental health impacts, particularly in the context of hurricanes, remain critically understudied due to challenges like data availability, stigma, and the complexity of accurately measuring psychological effects. Although some studies have explored the broader public health implications of climate change, there is a significant gap in understanding how hurricanes specifically affect mental health service utilization over both the short and longer term. This gap underscores the need for more targeted research that delves into the demand for and access to mental health services during and after disasters, and how these services can be integrated into disaster preparedness and response frameworks to better support affected populations.

This study addresses critical gaps in the literature by using encounter data to examine both the short- and longer-term effects of hurricanes on mental health service utilization. Employing a Difference-in-Differences (DiD) approach, the analysis disaggregates data to assess

the impact on specific conditions, including depressive disorders, schizophrenia spectrum and other psychotic disorders, bipolar and related disorders, suicidal ideation or attempts and intentional self-harm, and trauma- and stressor-related disorders. By breaking down the effects on these individual conditions, the study provides a nuanced understanding of how hurricanes influence mental health services over time, offering valuable insights for targeted interventions and disaster management strategies. Using detailed patient and visit-level data from all Florida hospitals, this study provides a comprehensive analysis of the impact of Hurricane Irma on mental health service utilization. By examining both short-term and long-term effects and distinguishing between new and follow-up visits across the top five mental health disorders, the study uncovers significant disruptions in care, particularly for depressive and trauma-related disorders. These findings highlight the critical role of continuity of care and the unique challenges posed by natural disasters, offering valuable insights for improving disaster preparedness and mental health service delivery in affected regions.

2. Literature Review and Research Background

2.1 Climate Change, Environmental Disasters, and Health Inequalities

The relationship between climate change, environmental disasters, and health inequalities is a growing area of concern, with far-reaching implications for public health. As climate change progresses, the frequency and intensity of extreme weather events—such as hurricanes, floods, and heatwaves—are expected to increase, posing significant risks to both human health and healthcare systems. Consequently, research has established that these risks are unevenly distributed, disproportionately affecting vulnerable populations, including low-income communities, people of color, and those with pre-existing health conditions (Ebi & Hess, 2020).Vulnerable populations, already burdened by structural inequalities, face heightened risks

due to their greater exposure, higher sensitivity, and lower capacity to adapt to these changes (Smith et al., 2022). For instance, heatwaves and poor air quality disproportionately affect individuals with respiratory conditions, while the psychological impacts of climate-related anxiety are more acutely felt among those already experiencing mental health challenges (Smith et al., 2022). Furthermore, communities with limited access to healthcare or those living in flood-prone areas are more likely to suffer adverse health outcomes during and after extreme weather events.

Beyond the immediate physical impacts, research has shown that extreme weather events also have complex and long-lasting indirect effects on health. These include the disruption of healthcare services, worsening of chronic conditions, and significant psychological impacts. The mental health consequences, such as anxiety, depression, and PTSD, are often underreported and inadequately addressed in disaster response frameworks.

Moreover, recent studies have highlighted the financial strain that exacerbate the consequences of natural disasters. Natural disasters can severely strain the financial resources of affected individuals and communities, leading to declines in credit health, increased debt, and reduced access to financial services. This financial stress compounds the health challenges faced by vulnerable populations, making it more difficult for them to recover from the physical and mental health impacts of these events (Ratcliffe et al., 2020). The literature underscores the interconnectedness of economic and health outcomes, particularly in the context of climate change-induced disasters.

While existing research provides valuable insights into the complex relationship between climate change, environmental disasters, and health inequalities, there is an urgent need for targeted public health interventions. The literature calls for more comprehensive data and

interdisciplinary research to fully understand these health impacts and to develop effective strategies for mitigating these risks (Smith et al., 2022; Ratcliffe et al., 2020). This paper addresses this call by providing empirical insights into the specific mental health impacts of hurricanes, offering evidence that can inform the design of targeted interventions aimed at maintaining mental health service continuity and improving long-term outcomes for vulnerable populations.

2.2 Hurricanes and Mental Health: An Understudied Area

Hurricanes are powerful natural disasters with significant and often understudied consequences for mental health. Understanding these impacts is crucial for developing effective public health strategies, disaster preparedness plans, and support services. Mental health is a fundamental aspect of overall well-being, and disruptions to mental health services during and after disasters can lead to long-lasting effects on individuals and communities. Despite the clear link between hurricanes and psychological distress, this area remains critically understudied.

Existing research supports the notion that extreme weather events, including hurricanes, have significant mental health implications. For example, studies have documented increased rates of anxiety, depression, and PTSD following such events, yet the nuanced patterns of healthcare utilization in these contexts remain under-explored. A recent study by Schwartz et al. (2022) highlights the growing phenomenon of climate change anxiety, defined as negative cognitive, emotional, and behavioral responses associated with concerns about climate change, which often overlaps with traditional psychiatric conditions like Major Depressive Disorder (MDD) and Generalized Anxiety Disorder (GAD). This anxiety, while pervasive, often goes unaddressed in disaster response efforts, leading to long-term mental health consequences (Schwartz et al., 2022). Further, the study by Garfin et al. (2022) points out that repeated

exposure to hurricanes can have cumulative effects on mental health, yet there is still limited understanding of how these effects manifest across different demographic groups and healthcare settings. This gap in the literature is particularly concerning given the potential for hurricanes to exacerbate existing health disparities (Schwartz et al., 2022). Similarly, research by Li et al. (2021) suggests that access to green spaces may buffer some of the mental health impacts of hurricanes, but this protective factor is unevenly distributed across communities, further highlighting the inequality in mental health outcomes post-disaster (Schwartz et al., 2022)

One of the primary reasons for the under-research of mental health impacts in the context of hurricanes is the pervasive stigma surrounding mental health issues. This stigma often discourages individuals from seeking help or discussing their psychological distress, leading to underreporting and a lack of visibility in both public discourse and academic research. Additionally, the complexity of diagnosing and measuring mental health conditions—particularly in the chaotic aftermath of a disaster—makes it challenging to capture accurate data. Mental health conditions are often more subjective and less immediately apparent than physical injuries, which can result in them being overlooked or inadequately addressed in research studies and disaster response plans. Furthermore, disaster response efforts have traditionally prioritized immediate physical needs, such as food, shelter, and medical care. While these needs are undeniably critical, the focus on them often means that mental health services are sidelined as a secondary concern. This prioritization reflects both logistical challenges and a historical underestimation of the importance of mental health in overall disaster recovery. As a result, the precise patterns of mental health service utilization following hurricanes, the factors influencing access to care, and the long-term psychological effects on different demographic groups remain poorly understood.

This study aims to contribute to the literature by providing a comprehensive examination of mental health service utilization following hurricanes. By focusing on a specific disaster type and utilizing detailed data on healthcare utilization, this research seeks to shed light on the immediate and longer-term mental health needs of affected populations. Additionally, the study will explore the role of demographic factors, such as age, gender, race, and socioeconomic status, in shaping mental health service utilization patterns. By identifying disparities in access to care and understanding the factors associated with successful mental health service utilization, this research will inform the development of targeted interventions and policies to improve mental health outcomes in the aftermath of hurricanes.

2.3 Information Systems and Operations Management in Disaster Management

Recent advancements in information systems (IS) and operations management (OM) have significantly enhanced disaster preparedness, response, and recovery, particularly through the integration of AI-driven platforms, cloud-based collaborative tools, and data analytics. These technologies enable real-time data sharing, predictive analytics, and optimization models that can drastically improve decision-making during emergencies. As we enter what some scholars refer to as "The Century of Disasters," characterized by an increase in the frequency, complexity, and magnitude of both natural and man-made disasters, the role of technology in disaster management has become more crucial than ever (Abbasi et al., 2024).

One of the key trends in technology-enabled disaster management is the use of AI and machine learning to develop early warning systems, enhance crisis communication, and optimize resource allocation during emergencies. These tools are increasingly recognized for their potential to improve the agility and effectiveness of disaster response efforts. However, for these tools to be truly effective in the context of mental health during hurricanes, it is essential to first

understand the patterns of healthcare utilization and the underlying factors influencing demand. Mental health services, unlike general healthcare services, require tailored approaches that consider the complexities of mental health conditions and the specific challenges posed by disasters (Zhang et al., 2024).

Moreover, the literature highlights the need for integrated decision-support systems that combine predictive analytics with real-time data to support more agile and informed decision-making in disaster scenarios (Gupta et al., 2016) . In the context of hurricanes, this approach could be used to anticipate surges in mental health service demand and ensure that resources are allocated effectively to meet these needs. However, these systems must be designed with a deep understanding of the unique dynamics of mental health service utilization during and after disasters, which has been underexplored in existing research.

The integration of IS and OM in disaster management also underscores the importance of socio-technical systems that account for the interplay between technology and human factors. For example, digital platforms that facilitate collaboration among various stakeholders—including healthcare providers, emergency responders, and community organizations—are essential for coordinating effective responses to disasters. These platforms must be designed to support the specific needs of mental health services, which are often marginalized in broader disaster management efforts (Abbasi et al., 2024).

This study examines the impact of hurricanes on outpatient mental health services, focusing on key disorders and both immediate and longer-term effects, which is crucial for designing IS and OM tools that are not only technologically advanced but also responsive to the real needs observed during disasters. Targeted interventions, informed by detailed knowledge of service utilization patterns and the mechanisms driving these patterns, can be more effectively

integrated into disaster management platforms, thereby enhancing the resilience and responsiveness of healthcare systems in the face of extreme weather events.

2.4 Summary of Contributions

This paper makes significant contributions across multiple streams of literature by integrating insights from environmental studies, healthcare, information systems, and operations management. It expands the existing body of research on climate change and health inequalities by focusing on the mental health impacts of hurricanes, a critically understudied area. By addressing challenges related to data availability, stigma, and accurate measurement in mental health research, the paper provides new insights into the psychological effects of extreme weather events and highlights the importance of mental health as a key component of disaster preparedness and public health.

Focusing on how hurricanes impact outpatient mental health service utilization, this study examines not only the total number of outpatient visits but also disaggregates the data to analyze the effects on the top five mental disorders: depressive disorders, schizophrenia spectrum and other psychotic disorders, bipolar and related disorders, suicidal ideation or attempts and intentional self-harm, and trauma- and stressor-related disorders. By assessing both the immediate and longer-term effects of hurricanes on mental health services, the study offers a comprehensive understanding of the demand and access issues surrounding these services during disasters.

In the realm of information systems and operations management, this research underscores that the effectiveness of advanced data analytics tools and disaster management platforms depends on a thorough understanding of healthcare utilization patterns. By informing the design of targeted, responsive tools that address specific challenges in mental health care during

hurricanes, this paper not only advances technological capabilities but also enhances practical outcomes in disaster management, ultimately contributing to the development of more resilient communities in a changing climate.

3. Data

Our primary data sources for this study are derived from the Healthcare Cost and Utilization Project (HCUP) of the Agency for Healthcare Research and Quality (AHRQ), specifically utilizing the State Ambulatory Surgery and Services Databases (SASD) for the state of Florida. We focused on the year 2017 and the first three quarters of 2018 to examine the impact of Hurricane Irma, which made landfall in Cudjoe Key, Florida as a Category 4 hurricane with 130 mph winds on September 10, 2017. Notably, no major hurricane had struck Florida since Hurricane Wilma in 2005, creating a 12-year period without significant storm activity. This gap, combined with the fact that the next major hurricane, Hurricane Michael, did not strike until October 2018, provided us with a unique window to study the immediate and longer-term effects of a significant hurricane event on healthcare utilization, without the confounding effects of previous or subsequent major hurricanes.

The SASD datasets offer comprehensive and detailed information on outpatient visits, including patient demographics (such as age, gender, race, and insurance status), diagnostic codes (including ICD-10 codes for mental health conditions), the quarter of discharge, and the number of days from admission to discharge (DaysToEvent). These variables allow us to analyze the timing and duration of healthcare encounters in relation to Hurricane Irma, providing valuable insights into how mental health service utilization fluctuated during and after the disaster.

A key feature of the data is the VisitLink identifier, a unique patient identifier that enables us to track a patient's visits across different hospitals over time. This longitudinal capability is crucial for understanding the continuity of care, particularly for chronic mental health conditions that require ongoing management. By utilizing VisitLink, we can examine patterns in hospital admissions, readmissions, and transitions between different care settings, and assess how these patterns were influenced by Hurricane Irma. This approach allows for a nuanced analysis of the impact of the hurricane on mental health services, providing a clearer picture of the challenges faced by the healthcare system in the wake of such a significant event.

We focus on the five leading mental disorders outlined in the Healthcare Cost and Utilization Project (HCUP) Statistical Brief (Fingar and Roemer, 2022). These include depressive disorders, schizophrenia spectrum and other psychotic disorders, bipolar and related disorders, suicidal ideation or attempt and intentional self-harm, and trauma- and stressor-related disorders. We classify mental disorders by utilizing CCSR codes, which consolidate ICD-10-CM diagnosis codes into a reduced set of clinically relevant categories. The corresponding CCSR codes and mental disorder categories are provided in Table A1 in Appendix.

4. Estimation Strategy

4.1 Affected versus Less-affected Counties

We adopted a difference-in-differences (DiD) approach to assess the impact of Hurricane Irma on mental health disorder diagnoses. DiD is a quasi-experimental technique that compares the changes in outcomes over time between a treatment group (affected by the event) and a control group (less or not affected), allowing us to isolate the effect of the hurricane from other factors. Following previous research (Mitsova et al., 2018), we define affected counties based on whether they experienced Category 1 hurricane-force winds (64 knots; 74-95 mph). As illustrated in

Figure 1 (adapted from fig.1 in Mitsova et al., 2018), 20 out of 67 counties in Florida were impacted by Category 1 hurricane-force winds, forming our treatment group. The remaining counties, which were affected by tropical storm force winds (34 knots; 39-73 mph), are classified as less affected and serve as our control group.

Figure 1. Hurricane Irma Path

Notes: This figure is adapted from 1 fig.1 in Mitsova et al., 2018.

We use the extent of damage as an alternative indicator to distinguish between counties that were more affected and those that were less affected. We obtained the catastrophe claims data for Hurricane Iram from The Florida Office of Insurance Regulation. This data provides the total number of damage claims for each county, which serves as a measure of the hurricane's impact. The average number of Hurricane Irma claims stands at 16,959.8. We categorize counties into three groups (terciles) based on the total number of damage claims. Counties with a higher number of claims are classified as affected, while the other two groups are considered less affected. The summary statistics for the number of claims for both the treated and control groups are displayed in Table 1.

Table 1. Summary Statistics of Damage Claims

	count	mean	std	min	max
Total Counties					
Number of Claims	65	16959.8	30926.26	34	152201
Affected Counties					
Number of Claims	21	47685.05	39716.44	10373	152201
Less Affected Counties					
Number of Claims	44	2295.47	2961.33	34	9714

4.2 Specification

To investigate the impact of Hurricane Irma on mental health disorder diagnosis, we estimate the following specification:

$$Y_{ijt} = \alpha + \beta\, Affected_{ij} \times Post_t + \lambda_{ij} + \mu_t + \epsilon_{ijt} \quad (1)$$

Where the Y_{ijt} represents the total number of mental health disorder diagnosis of patient i of county j at year-quarter t. $Affected_{ij}$ equals 1 if patient i of county j was affected by the Hurricane Irma. $Post_t$ equals 1 of year-quarter t is after quarter 3 of 2017 when Hurricane Irma happened. λ_{ij} is patient fixed effects that capture the time-invariant differences across

individuals. $\mu_t$denotes year-quarter fixed effects that account for temporal trends. The main effects of $Affected_{ij}$ and $Post_t$ are collinear with patient fixed effects and year-quarter fixed effects, and thus are dropped from the regression. β capture the impact of hurricane on mental health disorder diagnosis.

Instead of a two-way fixed effects model, we also use logistic regression to assess the probability that patients were diagnosed with a mental health disorder after the hurricane. Specifically, we adopt the following specification:

$$\Pr(Mental\ health\ disorder = 1) = \frac{1}{1 + e^{-(\alpha + \beta\, Affected_{ij} \times Post_t + \boldsymbol{X}_{ij})}} \quad (2)$$

Our dependent variable is binary, indicating whether patient i has a mental health diagnosis in year-quarter t. $Affected_{ij}$ equals 1 if patient i of county j was affected by the Hurricane Irma. $Post_t$ equals 1 of year-quarter t is after quarter 3 of 2017 when Hurricane Irma happened. We control for patient demographic characteristics such as age, gender, race, insurance type, and county. Additionally, we incorporate year-quarter as a control variable to account for time trends.

5. Results

Table 2 displays the summary statistics. On average, patients in counties affected by the hurricane had 0.136 visits for mental disorders each quarter before the hurricane and 0.148 visits afterward. Patients in counties less affected by the hurricane had 0.129 visits for mental disorders each quarter before the hurricane and 0.149 visits afterward. The descriptive statistics also highlight the varied patterns in health service utilization across different mental health conditions before and after Hurricane Irma, with noticeable differences between the affected and less-affected counties. Schizophrenia spectrum disorders showed a slight decrease in the mean number of outpatient visits in the affected counties, while the control counties saw no change.

The maximum number of diagnoses for schizophrenia spectrum disorders increased in the affected areas, indicating some instances of more severe cases. Depressive disorders experienced a less pronounced increase in the affected counties compared to the control counties, suggesting a difference in service utilization. Bipolar disorders remained stable in both affected and control counties, showing no significant change in outpatient visits. Trauma-related conditions slightly increased in the affected counties, while staying unchanged in the control counties. Suicidal ideation showed a small increase in the affected counties, while remaining constant in the control areas.

Table 2. Descriptive Stats of Mental Disorders Visits

	Before Hurricane					After Hurricane				
	count	mean	std	min	max	count	mean	std	min	max
Panel (A) Affected Counties										
All mental disorders	112,848	0.136	0.370	0	11	188,080	0.148	0.386	0	15
Schizophrenia spectrum	112,848	0.004	0.064	0	2	188,080	0.003	0.064	0	6
Depressive	112,848	0.114	0.343	0	11	188,080	0.126	0.360	0	15
Bipolar	112,848	0.014	0.125	0	3	188,080	0.014	0.126	0	4
Trauma-related	112,848	0.006	0.084	0	8	188,080	0.007	0.087	0	7
Suicidal ideation	112,848	0.0001	0.012	0	1	188,080	0.0003	0.018	0	1
Panel (B) Less-affected Counties										
All mental disorders	134,670	0.129	0.354	0	9	224,450	0.149	0.377	0	11
Schizophrenia spectrum	134,670	0.004	0.076	0	9	224,450	0.004	0.072	0	8
Depressive	134,670	0.103	0.318	0	6	224,450	0.124	0.348	0	11
Bipolar	134,670	0.014	0.128	0	6	224,450	0.014	0.128	0	8
Trauma-related	134,670	0.011	0.108	0	8	224,450	0.010	0.105	0	3
Suicidal ideation	134,670	0.0003	0.021	0	3	224,450	0.0003	0.020	0	2

5.1 Immediate Effect

We start by examining how Hurricane Irma affects mental health disorder visits of patients in affected counties, focusing on the immediate quarter after the hurricane. Table 3, Column (1) displays the primary effect, focusing on total number of outpatient visits for the top five mental disorders. In Columns (2) to (6), we examine the number of visits for each of the top five mental disorders individually. The findings indicate that, following the hurricane in the impacted

counties, the visit of Schizophrenia spectrum disorder significantly decreased by 25% ($0.001 \div 0.004 = 0.25$). While the number of visits of other mental disorders does not have significant changes.

Table 3. Immediate Effect of Hurricane Irma

	All Mental Disorders	Schizophrenia Spectrum	Depressive	Bipolar	Trauma	Suicidal ideation
	(1)	(2)	(3)	(4)	(5)	(6)
	Num of Visits	Num of Visits	Num of Visits	Num of Visits	Num of Visits	Num of Visits
$Affected \times Post$	-0.002	-0.001**	-0.002	-0.000	-0.000	0.000
	(0.003)	(0.001)	(0.003)	(0.001)	(0.001)	(0.000)
Patient FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	330,024	330,024	330,024	330,024	330,024	330,024
R-squared	0.19	0.34	0.21	0.29	0.27	0.27

Notes: * p< 0.1, ** p<0.05, *** p<0.01. Standard error clustered at patient level.

New Visits versus Follow-up Visits. To determine whether the decrease in mental disorder visits stems from demand-side or supply-side issues, we differentiate between new visits and follow-up visits, using the first quarter of 2017 as a baseline. Patients diagnosed with a mental disorder in the first quarter of 2017 are considered to have pre-existing mental health issues, and their subsequent visits are categorized as follow-ups. Other patients are categorized under new visits. The idea behind is that a decrease in new visits may suggest a demand-side effect, such as fewer individuals seeking initial treatment post-hurricane, whereas a decline in follow-up visits could point to supply-side challenges, such as diminished capacity for ongoing care due to disruptions in services.

The estimated results for new visits and follow-up visits are displayed in Table 4a and Table 4b, respectively. The data shows a significant decrease in the number of follow-up visits for mental disorders (as seen in Column 1 of Table 4a), while the number of new visits remained largely unchanged (Column 1 of Table 4b). Additionally, we noted a significant reduction in

follow-up visits for depressive disorders. This implies that the hurricane might have impacted the availability of hospital services, especially for depressive disorders.

Table 4a. Effect of Hurricane Irma on New Visits, Short-term

	All Mental Disorders	Schizophrenia Spectrum	Depressive	Bipolar	Trauma	Suicidal ideation
	(1)	(2)	(3)	(4)	(5)	(6)
	Num of Visits	Num of Visits	Num of Visits	Num of Visits	Num of Visits	Num of Visits
$Affected \times Post$	0.004	-0.001**	0.003	0.001	0.000	0.000
	(0.004)	(0.001)	(0.003)	(0.001)	(0.001)	(0.000)
Patient FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	217,011	246,552	222,423	244,167	245,478	247,452
R-squared	0.26	0.41	0.28	0.38	0.34	0.34

Notes: * p< 0.1, ** p<0.05, *** p<0.01. Standard error clustered at patient level.

Table 4b. Effect of Hurricane Irma on Follow-up Visits, Short-term

	All Mental Disorders	Schizophrenia Spectrum	Depressive	Bipolar	Trauma	Suicidal ideation
	(1)	(2)	(3)	(4)	(5)	(6)
	Num of Visits	Num of Visits	Num of Visits	Num of Visits	Num of Visits	Num of Visits
$Affected \times Post$	-0.013**	0.010	-0.015**	-0.006	-0.020	0.100
	(0.006)	(0.031)	(0.006)	(0.013)	(0.018)	(0.101)
Patient FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	30,507	966	25,095	3,351	2,040	66
R-squared	0.48	0.51	0.44	0.50	0.44	0.36

Notes: * p< 0.1, ** p<0.05, *** p<0.01. Standard error clustered at patient level.

5.2 Effect over Longer Time Window

Next, we analyze the effects of the hurricane over a longer time frame. Our observation period spans from one year after Hurricane Irma, covering from Q1 2017 to Q3 2018. We excluded Q4 2018 to avoid any confounding effects from Hurricane Michael, which occurred in October 2018. The estimation results are presented in Table 5. Column (1) of Table 5 indicates that the total number of mental disorder visits in affected counties decreased by 0.007, equivalent to a 175% ($0.007 \div 0.004 = 1.75$) reduction compared to the pre-hurricane period. Columns (2)

and (3) examine each mental disorder individually. The findings reveal a decrease in depressive disorder visits and an increase in visits of trauma-related disorders following the hurricane. The increase in visits for trauma-related disorders can be attributed to the intense and distressing experiences faced by individuals during and after the storm, which often lead to psychological impacts.

We examine whether the changes in visits are driven by supply-side or demand-side factors by differentiating between new visits and follow-up visits as described in Section 5.1. The estimated outcomes are presented in Table 6a and 6b. The findings suggest that the number of new visits for mental disorder diagnoses did not experience significant changes (Column 1 of Table 6a), while there was a decrease in the number of follow-up visits (Column 1 of Table 6b). Additionally, we observed a long-term decrease in the visits of depressive disorders, which is primarily driven by the reduction in follow-up visits (Column 3 of Table 6b). This implies that the disruption to hospital healthcare services caused by the hurricane may have persisted over a longer period. What's particularly interesting is that, in the long term (Column 5 of Table 5), we observed an increase in trauma-related disorders, primarily driven by new visits (Column 5 of Table 6b). This suggests that more patients developed trauma-related disorders after the hurricane, a trend often seen after disasters.

Table 5. Effect of Hurricane Irma over Longer Time Window

	All Mental Disorders	Schizophrenia Spectrum	Depressive	Bipolar	Trauma	Suicidal ideation
	(1)	(2)	(3)	(4)	(5)	(6)
	Num of Visits	Num of Visits	Num of Visits	Num of Visits	Num of Visits	Num of Visits
$Affected \times Post$	-0.007***	-0.000	-0.007***	-0.001	0.001*	0.000
	(0.002)	(0.000)	(0.002)	(0.001)	(0.001)	(0.000)
Patient FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	577,542	577,542	577,542	577,542	577,542	577,542
R-squared	0.06	0.19	0.08	0.17	0.15	0.15

Notes: * p< 0.1, ** p<0.05, *** p<0.01. Standard error clustered at patient level.

Table 6a. Effect of Hurricane Irma on New Visits, Long-term

	All Mental Disorders	Schizophrenia Spectrum	Depressive	Bipolar	Trauma	Suicidal ideation
	(1)	(2)	(3)	(4)	(5)	(6)
	Num of Visits	Num of Visits	Num of Visits	Num of Visits	Num of Visits	Num of Visits
$Affected \times Post$	-0.001	-0.000	-0.003	0.001	0.001**	0.000
	(0.003)	(0.000)	(0.002)	(0.001)	(0.001)	(0.000)
Patient FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	434,022	493,104	444,846	488,334	490,956	494,904
R-squared	0.07	0.21	0.10	0.20	0.18	0.17

Notes: * p< 0.1, ** p<0.05, *** p<0.01. Standard error clustered at patient level.

Table 6b. Effect of Hurricane Irma on Follow-up Visits, Long-term

	All Mental Disorders	Schizophrenia Spectrum	Depressive	Bipolar	Trauma	Suicidal ideation
	(1)	(2)	(3)	(4)	(5)	(6)
	Num of Visits	Num of Visits	Num of Visits	Num of Visits	Num of Visits	Num of Visits
$Affected \times Post$	-0.012***	0.012	-0.014***	-0.009	-0.024	0.100
	(0.004)	(0.031)	(0.004)	(0.010)	(0.016)	(0.101)
Patient FE	Yes	Yes	Yes	Yes	Yes	Yes
Year-quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	61,014	1,932	50,190	6,702	4,080	132
R-squared	0.28	0.32	0.26	0.33	0.25	0.21

Notes: * p< 0.1, ** p<0.05, *** p<0.01. Standard error clustered at patient level.

5.3 Alternative Specifications

In this section, we discuss the findings regarding the likelihood of patients being diagnosed with a mental disorder following Hurricane Irma, as calculated through Equation (2). The direct effects of the hurricane are detailed in Table 7. The data indicate a 5.7% decrease in the probability of being diagnosed with mental disorders in counties impacted by the hurricane, as shown in Column (1). We examine the top five mental disorders individually from Columns (2) to (6). It was observed that the probability of diagnoses for schizophrenia spectrum and depressive disorders fell by 27.1% and 5.6%, respectively.

Table 8 displays the impacts of Hurricane Irma one year following the event. Our findings indicate an 8% decrease in the overall probability of acquiring a mental disorder. Notably, the likelihood of being diagnosed with a depressive disorder dropped by 10.7%. More intriguingly, the probabilities of developing trauma-related disorders and suicidal ideation rose by 17.1% and 59.2%, respectively. These findings suggest that the hurricane had a negative effect on mental health outcomes.

Table 7. Immediate Effect of Hurricane Irma (Alternative Specification)

	(1) All Mental Disorders	(2) Schizophrenia Spectrum	(3) Depressive	(4) Bipolar	(5) Trauma	(6) Suicidal ideation
$Affected \times Post$	-0.057**	-0.271**	-0.056**	-0.0663	-0.004	0.515
	(0.025)	(0.136)	(0.027)	(0.068)	(0.094)	(0.466)
$Affected$	-0.064	-0.997**	-0.118**	-0.393**	0.912***	0.355
	(0.043)	(0.413)	(0.048)	(0.169)	(0.230)	(0.636)
$Post$	0.134***	0.011	0.141***	0.087*	0.100	0.095
	(0.019)	(0.097)	(0.021)	(0.052)	(0.063)	(0.333)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	327,112	324,272	327,112	326,828	326,636	258,756
Pseudo R-squared	0.01	0.08	0.01	0.03	0.12	0.13

Notes: * p< 0.1, ** p<0.05, *** p<0.01. Standard error clustered at patient level.

Table 8. Effect of Hurricane Irma over Longer Time Window (Alternative Specification)

	(1) All Mental Disorders	(2) Schizophrenia Spectrum	(3) Depressive	(4) Bipolar	(5) Trauma	(6) Suicidal ideation
$Affected \times Post$	-0.073***	-0.071	-0.094***	-0.077*	0.139*	0.506
	(0.017)	(0.089)	(0.018)	(0.046)	(0.063)	(0.334)
$Affected$	-0.147***	-1.196***	-0.187***	-0.409***	0.605***	1.011*
	(0.025)	(0.347)	(0.030)	(0.143)	(0.177)	(0.529)
$Post$	0.155***	-0.027	0.187***	0.064**	-0.029	0.163
	(0.012)	(0.061)	(0.013)	(0.032)	(0.038)	(0.201)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	572,446	572,012	572,446	572,418	572,418	471,821
Pseudo R-squared	0.01	0.08	0.01	0.03	0.10	0.10

Notes: * p< 0.1, ** p<0.05, *** p<0.01. Standard error clustered at patient level.

6. Discussion and Conclusion

This study provides a comprehensive analysis of the impact of Hurricane Irma on mental health service utilization in affected counties. The results highlight significant disruptions in outpatient visits for certain mental health conditions, both in the immediate aftermath and over the longer term. The most notable findings include a substantial 25% decrease in schizophrenia spectrum disorder visits immediately following the hurricane, while other mental disorders did not show significant changes in the short term. However, a deeper analysis distinguishing between new and follow-up visits revealed that the decline in mental health service utilization was primarily driven by a reduction in follow-up visits, especially for depressive disorders. In contrast, new visits remained relatively stable, suggesting that the disruption was more likely due to supply-side issues rather than a decrease in demand. Over the longer term, we observed a continued decline in visits for depressive disorders and a significant increase in trauma-related disorders, with the latter driven mainly by new visits, reflecting the psychological impact of the disaster.

The findings of this study have several important implications for healthcare management and policy, particularly in disaster-prone regions. The significant reduction in follow-up visits, especially for chronic conditions like depressive disorders, suggests that healthcare systems may struggle to maintain continuity of care in the wake of a disaster. This disruption can lead to worsening of symptoms and increased long-term healthcare needs, emphasizing the need for targeted interventions that ensure continuity of care for vulnerable populations during and after such events. Additionally, the increase in trauma-related disorders highlights the need for mental health services to be adaptive and responsive to the emerging needs of the population following a disaster. Policymakers should consider these findings when designing disaster preparedness and response plans, ensuring that mental health services are prioritized and that infrastructure is resilient enough to withstand and recover from such disruptions. Furthermore, the rise in suicidal

ideation post-hurricane underscores the need for accessible mental health crisis services to address acute mental health needs that may arise in the aftermath of disasters.

While this study sheds light on the impact of Hurricane Irma on mental health service utilization, several areas warrant further investigation. Future research could explore the long-term effects of disrupted mental health services on patient outcomes, particularly for chronic conditions like depression and schizophrenia spectrum disorders. Additionally, investigating the specific supply-side factors that contribute to the decline in follow-up visits, such as healthcare provider availability, infrastructure damage, and resource allocation, could provide valuable insights for improving disaster resilience in healthcare systems. Moreover, as trauma-related disorders showed a significant increase, further research could examine the effectiveness of early intervention programs and their role in mitigating the psychological impact of disasters. Finally, exploring the role of telehealth and other alternative care delivery methods in maintaining continuity of care during and after disasters could offer solutions to the challenges identified in this study.

In conclusion, this study highlights the complex and varied impact of Hurricane Irma on mental health service utilization, revealing critical insights into how different mental health conditions are affected by such events. The findings underscore the importance of robust and adaptive mental health services in disaster preparedness and response, with implications for both healthcare providers and policymakers in ensuring that vulnerable populations receive the care they need in times of crisis.

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Appendix

Table A1. CCSR Code for Five Leading Mental Disorder

CCSR Code	Category
MBD001	Schizophrenia spectrum and other psychotic disorders
MBD002	Depressive disorders
MBD003	Bipolar and related disorders
MBD007	Trauma- and stressor-related disorders
MBD012	Suicidal ideation or attempt and intentional self-harm