Quasi-Experimental Evaluation of Text-based Crisis Patterns in Youth following Hurricane Florence in the Carolinas, 2018

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ABSTRACT

IMPORTANCE Crisis text lines have proven to be an effective and low-cost means for delivering texting-based mental health support to youth. Yet there has been limited research examining the use of these services in capturing the psychological impact on youth affected by a weather-related disaster.

OBJECTIVE This ecologic study examined changes in help-seeking behavior for adolescents and young adults in North and South Carolina, USA, before and after Hurricane Florence (2018).

DESIGN AND MAIN OUTCOMES A retrospective, interrupted time-series design was used to examine pre- and post-hurricane changes in crisis text volume among youth help seekers in the Carolinas for the following outcomes: (1) text for any reason; (2) stress & anxiety; (3) depression; and (4) suicidal thoughts.

RESULTS Results showed an immediate and sustained increase in crisis texts for stress/anxiety and suicidal thoughts in the six weeks following Florence. Overall, an immediate 15% increase in crisis texts for anxiety/stress (SE=.05, p=0.005) and a 17% increase in suicidal thoughts (SE=.07, p=0.02) occurred during the week of the storm. Text volume for anxiety/stress increased 17% (SE=.08, p=0.005) and 23% for suicidal ideation (SE=.08, p=0.01) in the 6-week post-hurricane period. Finally, forecast models revealed observed text volume for all mental health outcomes was higher than expected in the 6 weeks post-Florence.

CONCLUSIONS AND RELEVANCE A low-cost, crisis texting platform provided 24/7 mental health support available to young people in the Carolinas impacted by Hurricane Florence. These findings highlight a new application for text-based crisis support services to address the mental health consequences in youth following a weather-related disaster, as well as
the potential for these types of crisis platforms to measure situational awareness in impacted communities.
INTRODUCTION

Climatic variability and associated changes in weather patterns are creating new mental health risks and exacerbating existing healthcare disparities (Dodgen et al. 2016, Berry et al. 2018). Since the early 1980s, significant changes in the intensity, frequency, and duration of North Atlantic hurricanes have been observed (Wash et al. 2014). A recent NOAA report concludes that both the intensity and associated rainfall of tropical cyclones are likely to increase during the 21st century due to anthropogenic climate change, although it is too soon to conclusively attribute observed changes so far to human activity (Knutson et al. 2019). In the Southeastern US, projected sea-level rise may exacerbate these events (Wash et al. 2014, Carter et al. 2018). The coast of the Southeastern region of the United States is particularly vulnerable to sea-level rise, storm surge, flooding, and hurricanes. In recent years, the Carolinas have been impacted by several billion-dollar events (losses in damage and life), including the record flooding in South Carolina in 2015 (Oct 1-5), Hurricane Matthew in 2016 (Oct 7-9), and Hurricane Florence in 2018 (Sept 13-18) (Carter et al. 2018).

Climate change is intensifying the risk, frequency, and severity of natural disasters, especially climate-sensitive disasters relating to hydrological and meteorological hazards posing significant threats to mental health and well-being (Dodgen et al. 2016). Roughly 1 out of 4 Americans are under the age of 18 (i.e., ~74 million) and recent estimates show that 14% of individuals in this age group have been exposed to a disaster in their lifetime (Disasters 2010). Dose-response patterns exhibiting increasing exposure and subsequent increases in a wide range of mental health consequences have been identified in adolescents post-hurricane, including serious emotional disturbances (McLaughlin et al. 2009), reactive aggression (Marsee 2008, Scott et al. 2014), depression, anxiety (Costa et al. 2009) and existential anxiety (Weems et al.)
2016), post-traumatic stress disorder (PTSD) (Goenjian et al. 2001, Kar and Bastia 2006, Kar et al. 2007, Yang et al. 2011), identity distress (Scott et al. 2014), sleep disturbance (Brown et al. 2011), and poor academic achievement (Scott et al. 2014). A significant number of empirical studies have documented the persistent effects of disaster-related stressors in young survivors for up to two years and beyond following a hurricane resulting in a disproportionately high prevalence of anxiety, depression, post-traumatic stress, and suicidal ideation (Acierno et al. 2007, Felix et al. 2015, Jacobs et al. 2015, Lai et al. 2013, McLaughlin et al. 2010, Osofsky et al. 2016).

While there are multiple drivers in the pathway of psychological disorders following a weather-related disaster, a few potential mechanisms in which climate may be linked to amplified mental health risks include: aggravating root causes of mental illness, traumatic experience, strain on public health-related resources, excess exposure to thermal stress, and loss of individual mental health resources (Berry et al. 2018).

Examining the mental health of youth post-disaster may serve as an indicator of recovery efforts and be used to inform targeted interventions in this high-risk group (Abramson et al. 2010). Crisis text-based counseling services have proven to be an effective and low-cost means of delivering mental health support to individuals struggling with thoughts of suicidality, hopelessness, and psychological pain (Gould et al. 2007, Kalafat et al. 2007). Yet limited research has examined the level of utilization of these mobile crisis counseling services in addressing the psychological impact on youth affected by weather-related disasters.

The objective of this retrospective, interrupted time-series study was to evaluate pre- and post-changes in crisis-support seeking patterns among youth impacted in the Carolinas (North Carolina and South Carolina) during and following Hurricane Florence in 2018. Our main
hypothesis concerning the impact model of Florence assumed text volume temporarily increased immediately and in the weeks after the storm (i.e., temporary level and slope change). To our knowledge, our study is the first to examine crisis help-seeking behaviors across a large population of youth immediately following a large natural disaster.

METHODS

Storm Impact on Study area

Hurricane Florence (Sept 13-18th, 2018) made landfall along the coast of North Carolina as a Category 1 storm (Stewart and Berg 2019). Florence was a slow-moving hurricane that generated more than 20 inches of rainfall along portions of the coasts of North Carolina (NC) and South Carolina (SC); whereby historic tropical cyclone rainfall records were exceeded in both states (NC: 35.9 inches for Florence (Elizabethtown) compared to 19 inches for Hurricane Floyd (Wilmington) in 1999; SC: 22.6 inches for Florence (Cheraw) compared to 17.5 inches for Tropical Storm Beryl (Lake Jocassee) in 1994) (Steward and Berg 2019). These high-volume rains, in turn, caused substantial low-land and river flooding throughout the Carolinas and surpassed flood stage records captured during Hurricane Matthew in 2016 (USGS 2019). The NOAA National Centers for Environmental Information (NCEI) estimated damages from wind and water during Florence resulted in $24 billion in losses (e.g., societal disruptions, property damage) and 47 deaths (Stewart and Berg 2019). The damage incurred from Florence in North Carolina exceeds the cost of damages exacted during Hurricanes Matthew (2016) and Floyd (1999) combined (Smith 2019). The region most heavily impacted by Hurricane Florence
flooding was predominantly rural inland counties in eastern North and South Carolina with lower

Data on crisis help-seeking patterns were obtained from Crisis Text Line (CTL), a global not-for-profit organization that provides free, 24/7 confidential crisis intervention via a text message platform to youth and young adult populations. Roughly 3 out of 4 CTL texters are below 25 years old, 14% report themselves as Latinx/Hispanic, and 6% report themselves as Native American (Crisis Trends 2018). These data have been used in the context of open data collaborators to understand the relationship between crisis-help seeking in response to temperature extremes (Sugg et al. 2019), the release of the Netflix series *13 Reasons Why* (Thompson et al. 2019, Sugg et al. 2019), and rural versus urban differences in the use of these technology-supported crisis interventions in youth (Thompson et al. 2018). The basic premise is that an individual in crisis can text into the service and be connected with a trained Crisis Counselor. Following each conversation, the counselor assigns data labels to the ‘texter’s issue’ or topic areas discussed (e.g., anxiety, stress, suicidal thoughts) based on a list of 35 options (see supplemental Table 1). In some scenarios, a texter can report multiple issues during a conversation. We then parsed crisis tags from CTL conversations to separately code and label the issues discussed for each crisis conversation.

Daily CTL conversation counts were aggregated for all NC and SC area codes for the following outcomes before and after the storm: (1) any crisis-text; (2) stress and anxiety; (3) depression; and (4) suicidal ideation. All crisis texts were deidentified to protect privacy and details on the user’s name, date of birth, phone number or contents of the message and were provided for 01 January 2018 to 31 October 2018. This time period was the only data available
for sharing at the time of the study team’s request. Data on demographic characteristics were available for a small subset of users (approximately 20% of texters) who agreed to supply these details through a post-conversation survey but were not included in the analysis due to the small sample size.

Since CTL’s inception in 2013, crisis counselors have facilitated over 155 million conversations with individuals in crisis. Although CTL crisis services are widely disseminated at the local community level through partnerships with schools, public health officials, and community partners, no strategic efforts are currently made to leverage existing dissemination channels to get the word out about these crisis counseling services in communities impacted by a weather-related disaster. To date, national crisis trends reflect that about 25% of texting volume in NC in SC have been related to anxiety stress (NC ranked 22 and SC 32 out of 50 states), 30 to 35% related to depression/sadness (NC ranked 10 and SC 11), and 20 to 25% related to suicide (NC ranked 39 and SC 43).

**Emergency Department Visits**

Daily emergency department visits for the same period 01 January 2018 to 31 October 2018 were obtained from the North Carolina Disease Event Tracking and Epidemiologic Collection Tool (NC DETECT), a statewide surveillance system. ED visits were categorized based on the following *International Classification of Diseases, Tenth Revision, Clinical Modification* (ICD-10-CM) diagnosis codes: 1) all mental health disorders (F00 to F99); 2) anxiety (F40 - F48); 3) depression (F32-F33); and 4) suicidal ideation (R45.851) (WHO 2004).

All ED visits were associated with the county of residence only for adolescents and young adults (age 15 to 24 years) impacted by the storm in North Carolina. Relying on FEMA
Disaster Declaration maps for North Carolina, we assigned each county to one of three Hurricane Florence exposure groups: 1) *directly impacted* counties defined as those who received both individual and public assistance; 2) *indirectly* impacted counties for those who received either individual or public assistance; and 3) *no impact* for counties who received no designation (FEMA 2018).

*Pre- and post-hurricane event periods*

The study period was restricted to Jan 1 to Oct 31, 2018, based on the available data provided by CTL. We categorized the pre-Florence period as Jan 1, 2018 to September 12, 2018, and the post-Florence period as of September 19, 2018 to October 31, 2018. To evaluate changes in crisis text volume in youth following Florence, we examined the immediate impact on CTL volume during the storm (September 13, 2018, to September 18, 2018) and for three separate post-hurricane scenarios: (1) *acute impact* on CTL volume in the two weeks post-Florence (September 18, 2018, to October 2, 2018); (2) *immediate, continuing impact* on CTL volume ~6 weeks after the storm (September 13, 2018, to October 31, 2018); and (3) *delayed, but continuing impact* on CTL volume 45 days after the storm (September 19, 2018, to October 31, 2018). The time-series included a total of 304 days of crisis-text observations, with 253 days of pre-Florence data and a post-Florence period of 51 days. The specified autoregressive (AR1) model included the effect of Hurricane Florence (i.e., I= intervention) on the dependent variable (i.e., daily crisis texts) during (September 13-18, 2018) and after the storm (September 19, 2018, to October 31, 2018):

Equation (1): 
\[ Y_t = \mu + \omega_1 I_{1,t} + a_t \]
where $Y_t$ is the dependent variable representing the logarithmic transformation of daily crisis text counts for each of the defined outcomes (i.e., daily texts for youth in North and South Carolina combined), $t$ indexes time, $\mu$ is the mean term, $\omega_1 I_1$ is the continual effect of the hurricane (i.e., referred to as the intervention) on the dependent variable during the subsequent 51 days, i.e., the percent change after the hurricane event. Log-transformed daily counts of crisis texts were used to stabilize variance and can be interpreted as a percent change in daily text volume post-Florence. The right-hand side of Equation (1) characterizes the AR(1) noise process; whereby $a_t$ is the random error term.

Statistical Analysis

Descriptive statistics were performed to examine the mean daily CTL volume with a 95% confidence interval for each pre- and post-hurricane event period. T-tests were used to examine whether mean daily CTL text volume for each outcome differed by the pre- and post-Florence period ($\alpha=0.05$).

We performed an interrupted time series (ITS) analysis to capture the immediate or gradual impact of crisis text patterns in the Carolinas before and after Florence. Autoregressive Integrated Moving Average (ARIMA) models were employed to analyze repeated measures of daily CTL volume data and address autocorrelation between time-series (Gebski et al. 2012, Penford et al. 2013, Wagner et al. 2002). ARIMA models are a flexible and sophisticated class of time-series models that allow for pre- and post-event hypothesis testing. We examined the various fit of autoregressive, moving average, or autoregressive moving average models by stepping through a standardized model fit exercise: (1) model identification, (2) parameter estimation, (3) diagnostic checking for each outcome, (4) pre-/post-event (i.e., intervention) testing, and (5) forecasting (Brocklebank et al. 2018). Model fit was assessed using a number of
measures: autocorrelation check for white noise, visual autocorrelation function (ACF), partial
autocorrelation function (PACF), and ICAF plots, AIC and SBC criteria, and residual correlation
and normality diagnostics were used to select the simplest and best-fit model. The forecasting
procedure in PROC ARIMA was used to generate one-step-ahead predictions of the time series
using historical data from the fitted model to compare actual versus predicted counts of daily text

Sensitivity Analysis: Changes in ED volume for NC

The storm impacted more individuals ($n=34,710$ applications approved for individual
assistance) and counties ($n=57$ out of 100 counties received major disaster declaration) in North
Carolina compared to South Carolina ($n=5,175$ applications approved for individual assistance,
19 out 46 counties received major disaster declaration). In a sensitivity analysis, we examined
pre- and post-Florence changes in NC emergency department volume for the following mental
health condition categories: 1) any mental health condition, 2) anxiety, 3) depression, or 4)
suicidal ideation/thoughts.

All ITS analyses were performed using PROC ARIMA in SAS 9.4 statistical software
and statistical significance was considered at $p<.05$ (SAS Institute Inc, 2014).

Results

Figure 1 shows daily CTL text volume for each outcome for the duration of the time
series (Jan 1 to Oct 31, 2018). CTL volume for any reason peaked 5 and 13 days after the storm,
while suicidal thoughts peaked around day 6 and depression peaked on day 13 post-Florence.
Table 1 shows the summary statistics on the daily mean for each outcome by the pre-/post-
hurricane period. We observed significantly more crisis texts for anxiety and stress, as well as
suicidal thoughts in the two weeks after Florence compared to the pre-event period. Daily text
volume for anxiety and stress, depression, and suicidal thoughts were significantly higher in the
six weeks after the storm compared to the pre-hurricane period.

*ARMA Models for Post-Florence Crisis Text*

The multiplicative autoregressive ARMA (1,0) model was the best-fit model to examine
the change in daily crisis text counts. We observed no seasonal lag in daily crisis text volume
within the period examined and therefore did not adjust for seasonality in our models. The
impact model results for each outcome for the different hurricane event scenarios are shown in
Table 2. We observed that shocks to the daily crisis text rate for each outcome during and
immediately after the storm were felt in subsequent days following the storm (Figure 2 a-d).

Results showed a statistically significant positive intervention effect for crisis texts related to (1)
anxiety & stress and (2) suicidal thoughts for the immediate, continuing impact period, as well as
the delayed, continuing impact period post-Florence (Table 2). We observed an immediate 16%
(SE=.05, \( p=0.005 \)) and 22% (SE=.07, \( p=0.02 \)) increase in crisis texts for anxiety/stress and
suicidal thoughts, respectively, immediately after the storm and a delayed 17% and a 23%
increase in texts for anxiety/stress (SE=.08, \( p=0.005 \)) and suicidal ideation (SE=.08, \( p=0.01 \))
after Florence, respectively. Although only marginally significant, a 20% (SE=.10, \( p=0.09 \))
increase in anxiety/stress texts were detected in the two weeks after the storm and an 11%
(SE=.06, \( p=0.08 \)) increase in depression-related texts occurred in the post-hurricane period.

Results confirm our hypothesis that Hurricane Florence generated an immediate and temporary
increase in crisis-text patterns in the six weeks following the storm.

*Forecast Modeling of Suicidal Thoughts*
Using the AR(1) model, we forecasted daily future crisis texts for youth in the Carolinas post-Florence for each of the intervention periods. The results are one-step-ahead predictions for the first 45 days after the storm. In general, crisis text volume was higher than expected for all four outcomes.

Sensitivity Analysis for NC ED Volume

Daily ED volume increased from the pre- (daily mean of ED visits = 64.5) to post-hurricane period (daily mean for ED visits = 73.0) for directly impacted counties ($t = -7.06, p < .0001$) compared to a decrease in mean ED post-Florence (pre-Florence daily mean for ED visits= 91.3 compared to post-daily mean= 83.7; $t=5.00 p < .001$) for the indirectly impacted communities and no change in ED volume for counties not impacted by the storm (Supplemental Figure 1). ED visits for any mental health condition in youth peaked around 8 days after the storm compared to visits related to depression that peaked around 2 and 5 weeks after the storm. Visits to the ED for suicidal ideation peaked around a week after the storm and then spiked again 5 weeks later.

Similar to the CTL analysis, we used the AR(1) model to examine the delayed, but the continuing impact of Hurricane Florence on changes in daily ED volume for each of the four mental health conditions in youth. After Florence, we observed a significant 16% increase in ED visits for all mental health conditions (Figure 3a), a 21% higher ED volume for depression (Figure 3b), a 33% increase in visits for suicidal ideation with a peak around 2 weeks and 1 month after the storm (Figure 3c), and 23% more ED visits for anxiety among youth (Figure 3d). ED volume for all four conditions abruptly dropped during the week of the storm for impacted communities.
General Crisis Trends

In general, we observed a spike in crisis texts for any reason, depression, anxiety, and suicidal thoughts in January and June of 2018. Some research has demonstrated similar trends concerning a winter peak in mental disorders (e.g., generalized anxiety and mood disorders) and a spring peak in mood disorders or major depression for younger age groups (deGraaf et al. 2005). As discussed in a related study, the spike in crisis text volume occurring in June 2018 may be attributable to two celebrity suicides and the release of 13 Reasons Why Season 2 (Sugg et al. 2019). Research has also shown an increase in crisis text patterns in the summer months during anonymously warm conditions in temperate climates (Sugg et al. 2019). Suicide rates generally exhibit a more seasonal trend with higher rates in the spring and summer. Yet, crisis text volume and ED visits for suicidal ideation were much higher post-Florence than patterns observed in the warmer season.

Discussion

This study examined the impact of Hurricane Florence on daily crisis text patterns for adolescents and young adults in the Carolinas. Our results are an original contribution to the literature and are the first to assess near real-time help-seeking behaviors in an impacted population before, during, and after a catastrophic hurricane. We found a significant and sustained increase in crisis-texts for two mental health variables – anxiety/stress and suicidal thoughts – immediately after Hurricane Florence. After controlling for recent shocks in local crisis text patterns (i.e., the AR(1) term), we conclude that the initial and sustained increase in the average daily volume of crisis-texts post-disaster is likely reflective of the mental health experience of impacted individuals in the Carolinas associated with Hurricane Florence and is not likely due to an alternative unobserved factor.
These results were confirmed by a sensitivity analysis examining changes in ED volume among those impacted communities in North Carolina. In general, we observed a 16% increase in any mental health-related ED visits for individuals between the ages of 15 and 24 after Florence. ED volume in this group was higher than crisis text volume for all three conditions: anxiety-related ED visits increased 23% (compared to 17% in CTL volume), depression-related ED visits increased 21% (compared to 11% in CTL volume), and ED visits for suicidal thoughts/ideation increased 33% (compared to 23% in CTL volume).

Typically, communities impacted by a natural disaster (e.g., catastrophic hurricane) do not have enough counselors trained to provide citizens with the mental health care services they need after a disaster, particularly during the acute impact period (Wang et al. 2007, Jaycox et al. 2010). Our results highlight a notable increase in help-seeking behaviors for trauma-related symptoms (e.g., depression, stress, and anxiety) following Florence. Pina et al. noted that greater helpfulness from extra-familial sources of social support predicted lower levels of self-reported symptoms of post-traumatic stress disorder, anxiety, and depression post-Katrina (Pina et al. 2008). It is encouraging that our results suggest adolescents and young adults are willing to seek help during an acutely vulnerable time through a text-based crisis counseling platform (i.e., Crisis Text Line) to address their distress versus a more traditional and potentially less accessible, clinic-based service.

We observed a significant spike in crisis texts and mental health-related ED visits for anxiety post-Florence. Our results are troubling as chronic anxiety is the strongest predictor for more severe, longer-lasting post-traumatic stress conditions among youth following other hurricane events, such as high-intensity storms Andrew (August 1992) and Katrina (August 2005) (Jaycox et al. 2010, Le Greca et al. 2013, Weems et al. 2007). Similar to our findings,
previous studies have documented an increase in mental health symptoms, including features of
PTSD, anxiety, and depression following large hurricane-related flooding events (Lieberman-
Cribbin et al. 2017).

Early disaster research has linked hurricane exposure with a 31% increase in suicides in
the two years following the event among populations directly exposed (Krug et al. 1998).
Research has also shown an increased prevalence of post-traumatic stress disorder, major
depressive disorder, and anxiety disorders, as important risk factors for suicidal thinking (Krug et
al. 1998, Nock et al. 2008, O’Connor and Nock 2008). Temporarily, we found a strong and
immediate short-term increase in help-seeking behaviors for suicidal thoughts following
Hurricane Florence and then a smaller delayed increase in texts associated with suicidal thoughts
within six weeks of the event.

Although our data stand in contrast to previous studies that either suggest a drop in
suicidality post disaster (Kolves et al. 2013) or as much as a 6 month delay in symptom
presentation (PTSD, suicidal ideation) following hurricane Katrina (Kessler et al., 2008), these
differences might be attributable to the differential methodological approaches across studies.
Our results were obtained spontaneously in real-time without formal recruitment, interviews, or
survey procedures, albeit during a shorter time frame (i.e., six weeks versus one-year post-
hurricane). Indeed, our results are the first to identify an increase in suicidal thoughts during the
acute impact phase and highlight the need to promote low or no-cost text-based mental health

crisis resources like Crisis Text Line.

Strengths and Limitations.
Our study contributes to the literature in several significant ways. First, unlike the previous research (Wang et al. 2007, Kessler et al. 2008, Galea et al. 2007), which focused on survey responses, psychometric screening scales, and clinical interviews, our study uses an interrupted time-series design. An interrupted time-series design accounts for confounding factors by taking into account pre-Florence trends to better characterize the impact (i.e., level, slope, and changing pattern) and thus is considered a robust tool for evaluating the longitudinal impact of a large scale hurricane (i.e., “natural experiment”) with a specific time of onset (Bernal et al. 2017, Kontopantelis et al. 2015). Additional strengths included the use of daily counts for texting behavior from a nationally available crisis text platform (\( n = 304 \) time points) compared to weekly or monthly counts which significantly increased the power to detect a true difference in crisis behaviors in the post-Florence period. ARIMA models also allow for the adjustment of autocorrelation to account for the delayed influence of crisis texts for a particular outcome earlier in the time-series and the detection of seasonality.

Additionally, our study examined a wide range of mental health symptoms of which individuals sought help, including stress, anxiety, depression, and suicidal thoughts; thus providing a broader assessment of mental health concerns and potential crisis events post-hurricane than previous studies which predominantly focused on PTSD and acute stress disorders (e.g., Norris et al. 2002). Our focused analysis of a text-based platform, which provides a more immediate method of capturing the psychological response of young people compared to traditional survey methodologies, may explain why our results differ from previous research.

Due to the small sample size of daily texts for each of the outcomes aggregated for North and South Carolina combined, we could not examine changes in daily text rates for individual area codes separately to approximate storm impact (i.e., tease out the difference between highest
exposed area and less-exposed areas). Further, because we used aggregated and de-identified crisis text data, we were unable to discern the effect of pre-existing mental health conditions (e.g., previous diagnosis of anxiety or depression) on post-Florence call volume. Research has shown that the mental health consequences of a disaster among survivors with a pre-existing mental health condition (e.g., anxiety, depression) are more severe compared to youth with new and emergent psychological sequelae (Storch et al. 2018). However, state-level data on emergency department visits and mental health care utilization for North Carolina in 2018 confirmed trends identified in the CTL text data and showed the magnitude of mental health conditions post-storm for youth in the most impacted areas. Future research is needed to confirm our findings in the context of other hurricanes impacting the Southeast and consider the mental health impacts of hurricanes that produce different effects than Florence (e.g., wind, storm surge, severe flooding).

Individual-level risk factors involved in influencing the differential effects of hurricane exposure and experience in youth (i.e., youth adaptation) are low socioeconomic standing, previous experience with a natural disaster, pre-existing mental health conditions (e.g., anxiety, depression, suicidal thoughts), social support, discrimination, and disruption in access to mental health services and medication (Weems et al. 2008, Warheit et al. 1996). We were unable to differentiate if individual-level factors influenced the magnitude of crisis events associated with the increase in adolescent texting behavior, despite previous research showing disparities in mental health outcomes post-disaster among specific sub-populations (Furr et al. 2010). CTL captures volunteer demographic data on texters by sending out a follow-up survey after the call, but only about 4 out of 10 texters complete the survey. Lastly, de-identified crisis conversations did not include information on the magnitude of impact for CTL-users post-storm, and if they or
their families were directly impacted through property damage, death, or injury or indirectly exposed as the result of repeated media exposure on the event. Proximity to hurricanes and hurricane-related impacts are important predictors for both immediate and long-lasting mental health impacts (e.g., Furr et al. 2010, Schwartz et al. 2017).

Directions for Future Research.

To date, no published studies were located that used CTL data to examine help-seeking behavior before and after a major hurricane. More research on determining the efficacy of CTL-derived preventive and early intervention crisis service delivery among youth is needed to understand how this low-cost service can be leveraged to reduce the psychological distress of weather-related disasters. Over two decades of research suggests that schools are a de facto mental health system for adolescents (Klontz et al. 2015, Taylor et al. 2012) and school-based interventions have shown a tremendous amount of potential for improving the mental health of this highly vulnerable group by providing enhanced social support (Goldman et al. 2015) and bolstering emotional well-being post-hurricane (Banks et al. 2014). A new avenue of research might involve coupling and mobilizing available services in the schools where these climate events take place and deploying them strategically and immediately in the aftermath (e.g., Banks and Weems 2014, Kirk et al. 2018, Capps et al. 2019). Strategic partnerships involving CTL, the public and mental health community, and schools located in disaster impacted areas may one day involve widely disseminating CTL services as a standard mental health crisis intervention protocol in disaster torn communities.

Now with the rapid pace and reach of these text-based media platforms, we have the capacity for situation monitoring to mitigate the impact of disasters in youth. CTL services could be used to target mental health and other social support resources for youth exposed to hurricane-
related stress and trauma in both the immediate and prolonged exposure periods. CTL can also be leveraged by the public health and disaster response community as a real-time screening tool to identify impacted areas with persons who are the most in need of supplemental mental health services and monitor the effectiveness of post-disaster mental health interventions.

Crisis text line counselors are volunteer-based and undergo a rigorous 200-hour training program. In addition, the current CTL volunteer workforce in the United States is substantial (approximately 5000). Training includes reflective listening, collaborative problem-solving, and crisis management; however, training materials do not specifically address how to respond to severe disruptions occurring in the aftermath of a natural disaster or extreme weather event.

Research examining the need for pre-event training among CTL counselors based on the core principles of Psychological First Aid (Brymer et al. 2006) can be used to identify areas in which counselors feel underprepared to address the mental health consequences in youth following a weather-related disaster.

**Conclusions.**

A lack of mental health resources has been cited as a significant challenge in the aftermath of weather-related disasters. This challenge is particularly problematic for adolescents and young adults, a group that is especially vulnerable to the mental health consequences of disasters and who are typically reluctant to seek help for mental health problems due to misinformation or perceived stigma attached to the receipt of these services. Critical to post-disaster recovery is the ability of a community to address mental health needs, specifically through adequate resources and timely interventions. Technology-based platforms, like Crisis Text Line, provide an opportunity for fast, cost-effective crisis counseling following natural disasters and can be used to lessen the mental health impact in youth post-disaster by increasing
the reach while simultaneously reducing the time it takes to access these safety net mental health services.

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